ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. 59. No. 15. 220 Broadway, New York, April 9, 1908.

TABLE OF CONTENTS.

	Page.
LEADING ARTICLES:	
A Combination Dam and Bridge (illustrated)	385
Conservation of the Natural Resources of the United States: The Work of the U. S. Geological Survey; Herbert M. Wilson, M. Am. Soc. C. E.	385
The Relation of the Engineer to the Conservation of Natural Resources; Willard A. Smith	390
Failure of an Old Railway Bridge in France (illustrated)	390
Cutting a Hole Through a Concrete Dam with an Air Plug Drill and Chisels; Ernest W. Schoder, Assoc. M. Am. Soc. C. E.	391
Hippodrome Building at Cleveland, Ohio (illustrated); James A. Joyce	392
A Report on Water and Sewage Purification Plants in Ohio	393
A New Ohio Water and Sewage Purification and Stream Pollution Law	396
A Graphical Comparison of Various Log Rules (illustrated); Arthur H. Morse.	396
How to Trap Rats	397
A Special Signal to Indicate Fires or Washouts at Railway Trestles (illustrated)	398
The Work of the Sanitary and Drainage Commission of Charlestown County, South Carolina	398
Apparatus for Preventing the Formation of Concrete Scale in Boilers (illustrated); M. Goldsdorf	403
Summary of Tests of Large Columns; Appendix E to Quebec Bridge Commission's Report (illustrated)	404
The Indian Creek Water Supply System of the Pennsylvania R. R. (illustrated); J. W. Ledoux, M. Am. Soc. C. E.	405
EDITORIAL	389
The Engineer and the Conservation of Natural Resources—Signs of Increase in Business Activity—The Movement for Safe School Buildings—Concerning the Manufacture of Public Opinion—Why the World Is Hollow.	
Advances in State Sanitation in Ohio	389
LETTERS TO THE EDITOR	401
The Designer of the Sluice Gates of the Laguna Dam; F. W. Hanna, M. Am. Soc. C. E.—Balanced Gate Valve Used on the Locks in the Muskingum River, Twenty Years Ago (illustrated); Cassius E. Gillette—A Hand Punch for Making Rivet Holes (illustrated); A. L. Campbell—Column Strength and Buchanan's Tests of Columns (illustrated); A. W. Carpenter—Diagram for Correcting Subchord Lengths (illustrated); C. M. Daily—Another Diagram for Computing Run-off (illustrated); Alberto Schreiner—The Replacement of the Erie Drawbridge Over the Cuyahoga River at Cleveland, O.; Mason R. Strong—Notes and Queries.	
ENGINEERING NEWS OF THE WEEK	407
PERSONALS	408
ENGINEERING SOCIETIES	408

A COMBINATION DAM AND BRIDGE.

At Horse Shoe, N. Y., in the Adirondack Mountains, just south of Tupper Lake, the Horse Shoe Forestry Co. is developing a 40,000 acre tract of timber land, so large and so devoid of roads that about a dozen miles of standard gage railway have been built to carry on the extensive logging operations of the company. Scattered through the property there are numerous streams which have been dammed and the generated power utilized in the transportation and manufacture of the lumber. At the Bog River one of these power stations has been built at a location favorable for the crossing of a branch of the logging railway, and advantage has been taken of the opportunity to combine the dam necessary for the power plant and the railway bridge. The accompanying half-tone shows the structure as built, with the water topping the crest of the dam and one of the small locomotives on the superposed railway track.

The dam is of the well-known Ambursen type, which has been described in Engineering News, Nov. 5, 1903, p. 403, and May 23, 1907, p. 557. This type consists of a reinforced concrete deck slab, in the shape of the ordinary gravity dam sections, supported at intervals by interior reinforced concrete buttresses. In the Bog River dam the bridge is formed by continuing these interior supporting buttresses up through the deck slab and carrying, upon their top, stringers bearing the railway. The whole dam is 250 ft. long, with a spillway of 70 ft., and is provided with a fish ladder, a log sluiceway and the usual penstock and waste gates. The deck slab, two feet thick at the base and one foot at the top, is supported on buttresses spaced every 10 ft. These buttresses vary in size with their position in the dam, and are braced together at the top by two reinforced concrete beams, 10 × 12 ins. in section, one on each side. The rails and ties are carried entirely free from the bracing beams, on 10 × 12 in. timber stringers dapped into notches on the top of the supporting buttresses.

In Fig. 2 the details of the fish-way are given. This consists of a four direction ladder made up of concrete pockets which hold pools of water. Small openings at the bottom of each pocket ensure a free flow of water and a possible passageway for the fish.

The design and construction of the work were carried out by the Ambursen Hydraulic Construction Co., of Boston, the president of which company, Mr. W. L. Church, M. Am. Soc. C. E., has furnished us with the above description.

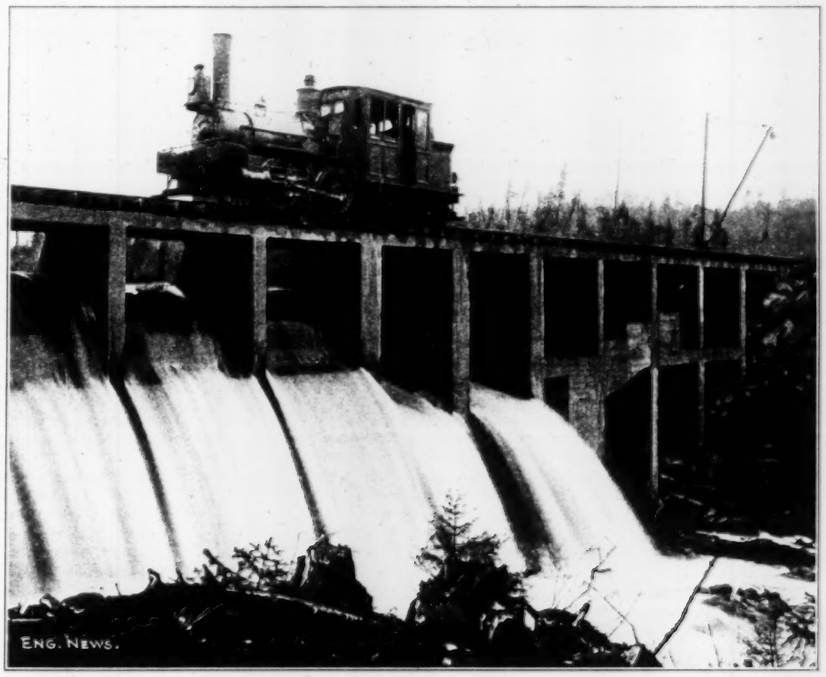

FIG. 1. A COMBINATION HOLLOW REINFORCED-CONCRETE DAM AND BRIDGE.
(Built by the Ambursen Hydraulic Construction Co., at Horse Shoe, N. Y.)

CONSERVATION OF THE NATURAL RESOURCES OF THE UNITED STATES: THE WORK OF THE U. S. GEOLOGICAL SURVEY.*

By HERBERT M. WILSON,† M. Am. Soc. C. E.

The wealth of the United States in natural mineral and agricultural products is being rapidly dissipated. Our resources in timber, fuel, minerals, land and water have seemed so unlimited that they have been given with prodigality to all who have applied for them. In the rush to make use of these resources and to acquire wealth through their development, we have lost sight of the fact that these natural products, however unlimited the supply may appear, may be ultimately exhausted by wasteful use.

Commenting recently on this condition, President Roosevelt said:

> The conversion of our natural resources to their proper uses constitutes the fundamental problem which underlies almost every other problem of our national life. Unless we maintain an adequate material basis for our civilization, we cannot maintain the institutions in which we take so great and so just a pride; and to waste and destroy our natural resources means to undermine this material basis.

The Geological Survey of the United States is occupied in the study of the mineral resources of the United States. Its labors have therefore been instrumental in attracting attention to the limitations upon such resources, and its efforts have been to show how these resources may be conserved and their life prolonged. The only other bureau of the Government bearing a similar relation to any natural resource is the Forest Service of the Department of Agriculture.

FOREST PRESERVATION.—The total stand of timber in the United States is 1,400 billion feet B. M. The annual use of timber is one-fourteenth of this, or 100 billion ft. B. M. The Forest Service therefore estimates that at the present rate of consumption, and neglecting renewals of growth, which on the average requires 25 years, our timber supply will be totally exhausted in 11 years. The Forest Service is accordingly making every effort to preserve this timber supply through the creation and proper management of national forests, and through instruction to States and to individuals as to how the forest resources may be utilized and how the trees may be cut in such manner as shall make every portion of the standing timber useful, and shall encourage a maximum of growth or replacement of the timber cut.

A little over 20% of our total forest area of 700 million acres is now included within State and national forest reserves, the remainder being on private land.

The great hope for the prolongation of the timber supplies of the United States lies in educating the people of the country to the necessity of scientifically managing the forests and the necessity of preventing waste. This means the use of every part of each tree cut; the stopping of destructive forest fires, which have consumed as much as has been cut; stopping destruction of young growth; stopping wasteful bark cut-

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†Chief Engineer, Technologic Branch, United States Geological Survey.

ting; and it means the employment of preservatives to prolong the life of the timber used.

Unfortunately, this matter has been taken up too late to gain all the benefit desirable. Prompt action, such as is being encouraged through the Federal Bureau of Forestry, may, however, place this country in a much better position than European countries, the forest resources of which were practically depleted before remedial measures were taken. The next and even greatest hope for the forest lies in the rapidly extending use of concrete as a substitute for wood in all kinds of buildings and structures.

LAND RECLAMATION.—The public lands available for agricultural use are practically exhausted. Public lands (of which the Government holdings are restricted now almost exclusively to the arid West) consist of the most desert or the most rocky, mountainous and inhospitable portions of the country. To provide additional homes for prospective settlers, every effort is being made by the Federal Government to make available and to safeguard its land holdings. The Reclamation Service, formerly a branch of the Geological Survey, and now an independent bureau, receives the proceeds of the sales of all public lands in the arid regions and utilizes them in developing the water supply for the irrigation of arid lands.

The Reclamation Service and the Geological Survey are now studying, as is the Department of Agriculture, the possibility of draining the waste swamp lands of the country and adding them to the available culturable areas. There are now irrigated about eight million acres of the most productive agricultural lands in the country. It is estimated by the Reclamation Service that in the next quarter century it may be possible to develop water supplies to irrigate a total of twelve million acres. This should provide homes for about two million people, who would be added to the productive population of the West.

There are about eighty million acres of swamp and overflowed lands in the United States, of which about twelve million acres are now drained and utilized for agricultural purposes. It is estimated that at a maximum, with Federal and State aid, twenty million acres may be reclaimed by drainage, thus adding sufficient productive lands to support an additonal population of perhaps four million people.

WATER CONSERVATION AND POWER.—The Water Resources branch of the Geological Survey is studying the streams of the country with a view to ascertaining their availability for the production of power, for the irrigation of arid lands, or the draining of swamp lands, and for domestic uses. Its work will result in conserving the water supply by the construction of reservoirs for the storage of flood flow and the increase of dry season discharges. It is well known that but a small proportion of the available water power in the streams is as yet utilized. Unfortunately no statistics have been gathered of the present state of development of water powers or their future possibilities.

The following approximate data, garnered from employees in various branches of the Geological Survey, are presented: In New England there is developed about one million horsepower, and there may ultimately be made available for power purposes a total of one and one-half million horsepower. In the Great Lakes region, the present development is one and one-fourth million, and the ultimate, four million horsepower. On the Atlantic and South Atlantic slopes, about one and one-fourth million horsepower is now utilized, with three million possible of development. In the Central and Northwestern States, one-half million horsepower is now developed, with a total of one million horsepower possible. In the Rocky Mountain and Pacific regions, one-half million horsepower is now being utilized, and five million may ultimately be developed. This gives a grand total of four and one-half million horsepower now developed from water powers, with a possible ultimate development of over fourteen million.*

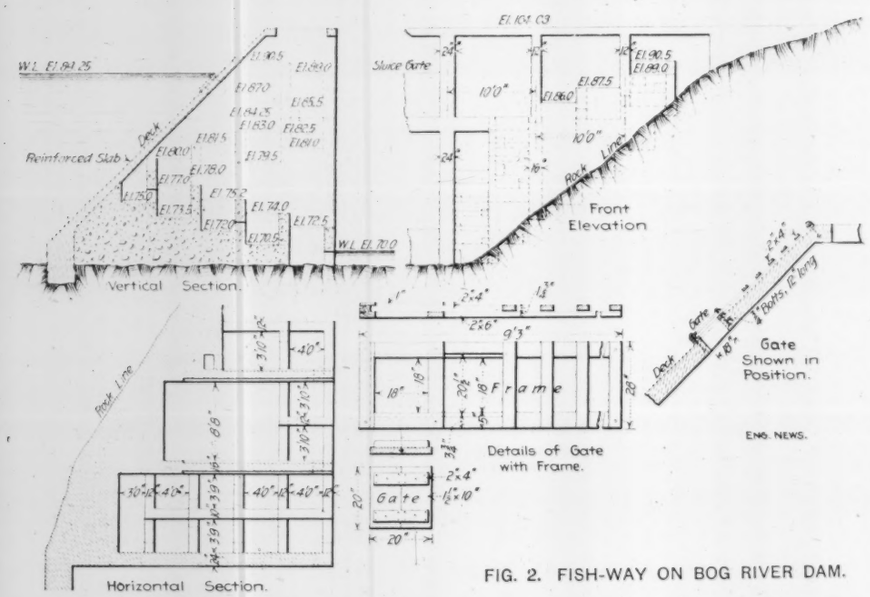


FIG. 2. FISH-WAY ON BOG RIVER DAM.

The work of the Water Resources branch in the past 15 years has shown many places where better power developments were available than those made use of. Nearly a million horsepower has been added in recent years to the useful water powers of the country. All this power is of value in performing its share of conserving the fuel supply of the country.

FUELS, MINERALS AND METALS.

The Technologic branch of the Geological Survey is charged with investigations the purposes of which are to conserve the supply of fuels and natural structural materials of the United States. This does not mean the restriction of the use of these materials, but the study of the causes which have led to the waste of the fuels and structural materials of the country and the devising of methods for conserving them and of utilizing them more efficiently, thus prolonging their life.

Among the means of preserving the supplies of structural materials are the investigations into methods of reinforcing concrete with steel; a survey and study of the cement-making materials and of the constituents of concrete, chiefly sand, gravel and broken stone, to determine their distribution and thus render them cheaper of local production; tests of various forms of steel rods and bars used in reinforcing concrete; a study of the properties of the various buildings stones and of clay and clay products, with a view to indicating more economic methods of use and production; and the use of all these structural materials as possible substitutes for the more perishable lumber and steel now entering so largely into building and engineering construction.

STRUCTURAL MATERIALS INVESTIGATIONS.

The amount of iron ore produced in the United States in 1906 was nearly 48 million tons, valued at over $100,000,000. The pig iron produced in part from this ore had a value of over $500,000,000. The iron and steel products resulting from the manufacture of this pig iron are estimated to exceed $700,000,000 in value. The clay products were valued at $160,000,000; the cement at $55,000,000; the building stones at $66,000,000, and the lime, sand and gravel, slate, mineral paints, etc., were valued at $40,000,000 more. The total value of the raw structural materials being investigated by the Geological Survey is over $820,000,000, considering the pig iron and not the iron ore as a raw material, while the value of the products manufactured therefrom is about $700,000,000 more, or a total annual value of $1,500,000,000.

As showing that the iron ore resources are not limitless, a careful estimate recently made by a Swedish geologist, corrected by a specialist in the Geological Survey, shows that the total iron ore now in sight in the world is only 25,000 million tons, of which there are 15,000 million tons in the United States. The annual consumption of this in the world is 100 million tons, and in the United States 35 million tons. Should the rate of consumption of iron ore increase in the United States in the same ratio as it has increased during the past 20 years, the supply of iron ore in the United States will be exhausted in 200 years.

The raw clay, cement-making materials, sand and gravel in the United States are practically unlimited in amount. We must, therefore, look to these as substitutes for iron and timber in all structural work, if the life of the latter is to be extended for any reasonable period. It is unnecessary to add that great progress has already been made in devising means of using clay products, chiefly brick and tile, and cement products, chiefly concrete and reinforced concrete, in those buildings and engineering works which have heretofore been made exclusively of wood and steel.

The building operations of the leading cities in the United States amounted to nearly $650,000,000 in 1906. Against this, the cost of fire to the country (including not only property destroyed, but maintenance of fire departments, payment of insurance premiums, so-called curative agencies, and other incidentals) amounted to over $500,000,000 in 1906, or over 80% of the value of the total new building construction. This fire tax exceeds the total annual value of gold, silver and coal production. The annual fire loss in the United States is, according to the National Board of Fire Underwriters, $2.47 per capita, while the average annual loss in six large European countries is only $0.33 per capita, or one-eighth that of the United States. In addition to the loss of property, there has been destroyed in this country by fires 6,000 human lives in one year's time. Undoubtedly the greater part of this immense waste in money and lives could be prevented by proper construction of houses, factories and business buildings. Such construction would not only cost little more than the prevalent combustible buildings in the first place, but also would result in real economy in the long run.

With the problems arising from the waste of money in perishable construction and with the growing scarcity and consequent increase in the price of wood, the search for desirable substitutes for timber becomes a matter of prime importance and justifies the work now being done by the United States Geological Survey at its structural materials laboratories at St. Louis.

The purposes of these investigations are:

(1) An investigation of (a) the nature and extent of the materials available for use in building and construction work, giving special atten-

*We believe this figure may be enormously increased.—Ed. Eng. News.

on to materials available for Government work; (b) where they can be best obtained; (c) how they can be used most efficiently under different conditions; (d) their strength at different temperatures and the fire-resisting qualities of the materials; (e) the strength of the steel frames of buildings at different high temperatures and how the steel can be protected best from fire by inclosing it with different materials; (f) the extent to which concrete, made from cement and local materials, can be safely and efficiently used under different conditions; (g) the materials in different parts of the country suitable for the manufacture of cement; and other similar problems.

(2) An investigation of the properties of clay.

(3) An investigation of building stones.

The structural materials investigations of the Geological Survey are being conducted principally at St. Louis, although supplemental work is being done at Norfolk, Chicago, New York, Lafayette, Ind.; Urbana, Ill., and Madison, Wis. The equipment of the laboratories at St. Louis is very complete, comprising four 200,000-lb. testing machines, one 100,000-lb. testing machine, one 600,000-lb. vertical testing machine, three concrete mixers, five block machines, and a great deal of smaller apparatus necessary for carrying on the work.

Already valuable work has been done by the Government at the St. Louis laboratories; to the present time 39,314 test pieces of concrete have been made; 52,531 tests of all kinds have been made, and 10,000 chemical determinations. Of these tests more than 15,000 were of aggregate of concrete in transverse specimens, cylinders and cubes; more than 12,000 were tensile tests of cement briquets; plain and reinforced concrete beams of full size were tested to the number of 2,556 pieces; full-size building blocks to the number of 2,218, and in addition 2,100 permeability and shear tests were made, and 12,670 physical tests of concrete and of reinforcing steel.

During the coming year it is proposed to make a series of tests on large columns, beams and floor slabs. The 600,000-lb. vertical testing machine referred to above is equipped for compressive and tensile tests of columns and beams up to 30 ft. in length.

The publications so far issued include reports on the effects of the San Francisco fire and earthquake on buildings; the results of 25,000 tests of the constituent materials of concrete; the equipment and methods of the structural materials testing laboratories; the results of tests of 100 plain concrete beams, etc.

CLAY INVESTIGATIONS.

The great need of systematic study and testing of the clay products of the country is shown by the appointment of a special committee of the American Ceramic Society last year. This committee submitted a report urging the U. S. Geological Survey to extend its investigations into the clays which furnish two of the most important structural materials—bricks and terra cotta—used in the country. This committee stated that such testing could only be done properly under the auspices of the Federal Government, as states could only do testing for the special needs of the states, while individuals and societies could not furnish conclusive results.

Clayworkers are unable to-day to prophesy from ordinary examinations or tests of clays whether they are best suited to make pottery of high grade, brick, terra cotta, stoneware or sewer pipe. There is no way of determining what color a clay will have when burned under various conditions. Clays which appear to be identical give products of various colors and physical properties. Tests must therefore include investigations into bonding power, plasticity, speed of drying, slaking, color, volume change, rate of porosity, proper speed of cooling, etc.

Investigations into the matter of clay distribution and properties of clays carried on along road lines, as are the investigations into cement, sand, gravel and broken stone which enter into concrete, would frunish information of the highest economic value to the people of the country.

FUEL INVESTIGATIONS.

The annual value of fuel resources of the United States closely approximates that of the structural materials. The total amount of coal mined in 1906 was 400,000,000 tons, valued at $510,000,000; the value of petroleum was $90,000,000; of natural gas $50,000,000. The coke made had a value of $110,000,000; artificial gas $30,000,000; by-products of coking $5,000,000; or a grand total of fuel values of $790,000,000, and including all by-products of petroleum, coals, etc., $1,000,000,000.

The sources of the waste of fuel are many. We are all familiar with the manner in which natural gas is wasted by allowing it to exhaust into the open air, great quantities being burned in the day time as well as night.

Veins of coal 6 or 8 ft. in thickness are often so mined as to leave 2 or 3 ft. of fairly good coal on the roof and floor of the mine, only the very best being shipped in view of the demand for the highest grade product. Great quantities of the coal actually mined are sorted over and cast on the culm bank. This waste coal could be converted into power through a gas-producer plant, or could be briquetted and made available as useful fuel. In one case, which may be cited from among the tests at the Government Fuel-Testing Plant, more power was gotten out of a low grade lignite by utilizing it through a gas producer and engine, than was being procured from good Pennsylvania coal burned under the steam boiler. This lignite had been previously thrown away.

Experiments in coking at the testing plant showed that fair coke can be produced from coals classed as non-coking, by mixing with them from 10% to 25% of pulverized coking coal, or small proportions of pitch.

The purposes of the investigation of fuels by the Government are:

(1) To lessen the waste of the nation's fuel supply; by showing how those fuels can be mined and used more efficiently.

(2) To extend the nation's supply of fuel, and lessen the transportation cost by indicating how lignite, peat and other materials, now little used, may become locally valuable as fuels in portions of the country having no ordinary coal.

(3) To find how to prevent the spontaneous combustion of coals in storage, on ships, at naval stations, mines, etc.

(4) To remedy the loss sustained in the production of fine coal in mining, through slaking, etc.

(5) To demonstrate the saving of by-products now wasted in the manufacture of coke, which if completely saved would be worth at present prices more than $50,000,000 yearly, and prevent large imports of such by-products.

The present waste of fuel is due to the following general causes:

(a) Approximately 50% of the possible coal supply is now lost by being left underground or wasted before reaching the furnace; in this manner $200,000,000 of fuel values are lost annually.

(b) Of many Mississippi Valley and western coals from 30 to 50% of the total product mined comes out in the form of "slack," which is often sold at less than cost, or accumulates and is burned about the mines.

(c) Of the fine portion of these Mississippi and western coals put into furnaces often 10 to 25% is lost in the ashes unconsumed.

(d) Of all the coal actually burned only about 5% of its heat units are actually converted into work.

(e) In the coking of 40,000,000 tons of coal yearly, there are now wasted ammonium sulphate enough to fertilize our crops; creosote enough to preserve our timbers; pitch and tar enough to roof our houses and briquette our slack or waste coals.

The investigations so far have demonstrated:

(1) The possibility of utilizing for power purposes the large and undeveloped areas of lignite and low grade coals of the West and Southwest.

(2) The practicability of using in gas producers for power purposes ordinary bituminous coals and lignites and of thus obtaining from each ton of coal more than 2½ times as much power as is obtainable in ordinary steam power plants.

(3) The possibility of making coke from a number of coals not considered generally as coking coals.

Some of these results are not only new but were believed to be impracticable when these investigations were begun.

In the ordinary steam boiler plant the efficiency varies according to the engine employed and the quality of the installation from about 4% of the energy of the coal transferred into actual work up to as high as 10% in the most modern steam plants. Recent experiments in the utilization of fuel in gas producers and its conversion through the medium of gas engines into power, indicate that the efficiency of the best gas power plants averages about 13% and may vary from 11 to 18%. The average of a large number of gas producer tests made by the Geological Survey on coals from all parts of the country, fuel from the same mine being tested at the same time in a steam boiler plant, indicates that a coal will produce about 2½ times as much power per pound consumed through a gas producer as through a steam boiler plant. For the best Pocahontas coal the steam plant produced 0.28 HP. per lb. of coal per hour and the gas producer 0.96 HP., or 3.34 times the efficiency for the producer-gas plant over the steam plant.

Most important, however, is the fact that the producer-gas plant will operate successfully on coals high in moisture, such as the lignites, of which there are millions of acres in the West, and the poor bone coals of Missouri, Arkansas and neighboring states, which are very high in ash and will not produce steam economically under a boiler. The lignites in the steam boiler tests produced but 0.01 HP. per lb. of coal per hour against 0.35 HP. per hour in the producer-gas plant. The most remarkable feature of this comparison was, however, the fact that the best Pocahontas steaming coal under the steam boiler produced 0.28 HP. per hour, while a lignite produced 0.30 HP. per hour when operated in the producer-gas plant, or 1.04 times the power of the best steam coal burned in a boiler furnace.

It became evident early in the fuel investigations that the greatest possible saving and consequent prolongation of the life of the fuel resources of the country might be had through a more rational utilization of the low-grade fuels. In the bituminous coal fields, especially in the Middle West and Southwest, where the coals are poor, the mine vein may run but 2 or 3 ft. of good merchantable steaming coal, but to mine this the tunnels and drifts must be opened out perhaps to a height of 6 ft. This means that from 2 to 4 ft. of material, often containing quite a quantity of medium-grade coal, is rejected to the culm bank. Means of burning the whole run-of-mine coal as mined, or of burning the bone coal alone, may be devised, which will make the entire product mined of value for heating and power purposes. Low-grade fuels are also utilized successfuly by compressing them into briquets. This briquetted coal requires a binding material of from 4 to 7% of pitch to hold it together. This pitch adds carbon and volatile matter to the briquet which helps the combustion, even though the ash content may be high.

The extensive peat deposits of the country are available in small measure for the production of coke, gas and oils through the Zeigler process, and may be utilized in a producer-gas plant, and because of its high nitrogen content, as a body for manufactured fertilizers.

In addition to the culm banks and wash banks, coke breeze and coke dust now wasted in large quantities may be utilized in gas producers or by briquetting. And finally, the refuse and coal dust in the coal yards of city dealers which has a market value under 60 cts. per ton and which is now wasted, may be briquetted for a little over one dollar per ton and sold for several times this price for local domestic and industrial purposes.

President Roosevelt has shown his customary foresightedness in bringing the fuel problem to the attention of the country in his last two mes-

sages to Congress. He has issued a proclamation withdrawing temporarily from sale sixty-four million acres of valuable Government coal lands in the West, which was rapidly passing into private ownership for the nominal price of $1.25 per acre when actually worth ten to fifty times this sum.

FUEL VALUE OF LIGNITES. There are in the western part of the United States, from North Dakota and Washington to Texas, vast areas of low-grade or young coal known as brown and black lignite. This fuel is very high in moisture and therefore does not burn freely on a grate. It has been found to be, however, even a better gas producer than many of the bituminous coals. In Germany the consumption of lignites has increased enormously in recent years, owing to the scarcity of coal. Lignite is there the chief domestic fuel. In 1865 Prussia produced 90,000,000 tons of coal and 5,000,000 tons of lignite. In 1905, 40 years later, they produced 143,000,000 tons of coal worth $250,000,000 and 41,000,000 tons of lignite worth $25,000,000. This lignite is rapidly becoming more valuable, however, owing to the introduction of by-product recovery processes which furnish paraffine and brown coal-tar oils. Another valuable product of the coal-tar industry is benzol which as a fuel is fast replacing gasoline for small internal combustion engines besides which its cost is much less and it is more economical and safer in operation.

The German lignite briquetting engine of the fuel-testing plant of the Geological Survey is expected to indicate valuable results in the utilization of our western lignites. The great difficulty with the fuel supply of the northwest is the impracticability of storing the western coals which readily slack and are subject to destruction through spontaneous combustion. The briquetting of these coals, however, renders them capable of storage for long periods without slacking or danger of spontaneous combustion.

In Germany the briquetting of lignite has increased nearly 800% in 13 years or from 272,000 tons to 2,117,000 tons. These briquettes are sold at less than $2.50 per ton and for industrial purposes for less than $2 per ton. When briquetted the lignite burns excellently both in the domestic fire and in the gas-producer.

PEAT.—Perhaps 10 to 20% of the 80,000,000 acres of swamp land of the United States are underlaid with peat of more or less value. The utilization of peat as a fuel is as old as man. The people of Ireland and other portions of Europe have always used it for domestic purposes. As wet peat in the bog is exceedingly heavy, all methods of handling it require substantial machinery and much hand labor, both of which are expensive. The only way in which these conditions may be improved is by manufacturing it on a large scale and wholly by machinery. In this country over a dozen companies have been started from time to time to utilize peat, but all have failed because they could not produce marketable fuel to compete with the still relatively low-priced coal.

In handling peat nearly all commercial plants use five processes; namely, the digging of peat from the bog by machine or hand; transporting it by mechanical or other conveyance to the mill; disintegrating it, or shredding the particles of peat; molding it into bricks; and finally drying it by natural exposure until the water content is reduced to 15 or 20%. Tests of peat were made by the Fuel Division on Florida and Massachusetts peat. The peat bricks when dried had an average moisture content of 21%. The steam boiler tests were inconclusive, only 0.14 of one electrical horsepower being produced from one pound of dry peat, while from good steaming coal about 0.33 of one electrical horsepower was produced from one pound of coal. Only one short steaming test in one type of furnace was made, due to lack of fuel. The more extended tests planned for the future may yield other results.

The producer-gas test was continued for 50 hours and showed relatively excellent results for peat as a power producer. The peat burned freely and completely. The gas had a fuel efficiency of 166 B. T. U. per cu. ft., as compared with 142 to 150 B. T. U. per cu. ft. of gas made with bituminous coal. This higher efficiency than coal gas is due to the higher relative hydrogen content of peat. One horsepower was developed at the gas engine for each 2.7 lbs. of peat consumed in a gas producer, as compared with 1.8 lbs. of Indiana coal, and as low as 1 lb. of best West Virginia coal.

Ordinary dried peat contains 6,800 B. T. U. per lb. Peat briquets contain over 10,000 B. T. U. Peat coke from 12,000 to 14,000 B. T. U., or about the same as raw anthracite and bituminous coal.

The cost of production of cut peat varies from 50 cts to $1 per ton; machined peat, from $1 to $1.50 per ton; dried and briquetted peat, from $2.50 to $3 per ton. This latter is a marketable product and is therefore comparable with coal. Peat coke, which is an excellent fuel, costs when manufactured by the Zeigler process from $2 to $2.15 in Europe, probably considerably more in the United States. The Ziegler process makes coke from peat and renders the by-products available for commercial use. Among the more valuable by-products of peat are acetate of lime, sulphate of ammonia, methyl alcohol, light and heavy oils, tar, paraffine and asphaltum. The greatest value in peat, however, lies in the amount of nitrogen it contains, and its consequent availability as a medium for carrying high-grade chemical fertilizers.

[The present commercial aspects of the peat industry are also well shown by an account of the organization of the American Peat Society, Engineering News, Oct. 31, 1907.—Ed. Eng. News.]

MINE CULM AND COKE BREEZE.—Vast quantities of low-grade coal have changed the face of the topography in the neighborhood of collieries. Enormous quantities of culm and the refuse from washeries, which are so high in ash content that they have been considered valueless, are piled up. This material may be utilized however for the production of gas in a special type of producer which renders the product suitable for heating, lighting or power purposes. Producer-gas power plants may be located at these culm banks, and thence distribute electrical power to the surrounding region. Similarly, the washery refuse which has been found high in nitrogen has been used in a special type of gas producer which renders available as a by-product large quantities of sulphate of ammonia, one of the most valuable of the fertilizers.

Coke dust and coke breeze accumulate near coke ovens and about gas works in great quantities. Their high ash and dust content have heretofore rendered them of little value. Now they are being utilized efficiently both in gas producers and for briquetting, which processes render them capable of competing with the best grades of coal.

PURCHASE OF COAL UNDER SPECIFICATIONS.—The people of this country have been purchasing coal for years on the statement of the selling agent as to its quality, or else on the reputation of the mine or district from which it was obtained. Even the farmers of this country have shown greater foresight in the purchase of fertilizers, which they pay for only on the basis of certified chemical analyses.

The aim in the purchase of coal for any power plant should be to obtain a fuel which will produce a horsepower for the least cost. By purchasing in the prevalent manner the buyer has been unable to take advantage of the competition which results from the submission of prices by a number of bidders. He has been afraid to buy from any but such dealers as he knew and trusted and if his coal did not prove satisfactory there was no standard for settlement or for cancellation of contract. These same men, manufacturers and officials of large manufacturing concerns, purchase many thousands of dollars worth of coal annually in this manner but would consider it ridiculous if they were asked to contract for the purchase of machinery or for a building, costing a fraction of the amount involved, with no specification except that it would be of a certain size and well constructed.

The purchase of coal on specification, which includes a chemical analysis of the coal, is as advantageous as a definite understanding regarding the quality of any other purchase, a building operation or an engineering project. The purchaser who buys under a specification gets what he pays for and pays for what he gets. The bidder also when allowed to specify the quality of the coal he proposes to furnish, as determined by chemical analyses, is placed on a basis which is strictly competitive with respect to other bidders. This specification therefore broadens the field both for the bidder and the purchaser. It furnishes a basis for settling disputes regarding the quality of the coal delivered and the price to be paid, providing the fuel be either better or poorer than guaranteed. A basis of settlement is even furnished if another coal than that called for be substituted. Under the prevailing method of purchase the buyer will seldom reject the poorer quality of coal, because of the difficulty, delay and cost of removing it from the bins. He will be confronted with the alternative of burning the coal delivered or going without fuel until more can be procured. Consequently unless the coal is very bad it is usually expedient to use it. In the purchase of coal under specification penalties are exacted when the fuel delivered is not up to the contract. This arrangement is more favorable also to the contractor since to remove the coal after delivery would be costly, and it would not be satisfactory as a fuel to any other purchaser.

At present the Government is purchasing anthracite coal for about 40 departmental buildings in Washington and for public buildings throughout the country on a simple specification, the prime elements in which fix the amount of ash at 10%. Premiums are paid for any decrease in the ash content up to 2% above the standard, and corresponding penalties are fixed for any increase in ash above the standard. For bituminous coal purchases variations in ash content of 2% above and 1% below standard are allowed before penalties or premiums are paid, and in addition the heating value is an element in the contract.

The essential feature of any method of purchasing coal on specification is the sampling. If samples are taken from a shovelful out of the top of a car they may be much freer from ash than samples taken from the bottom where as much as 8% more ash may be found. The moisture, too, will vary from top to bottom, depending upon the weather. More or less handling of the samples may introduce extraneous matter which will vitiate the analysis. The one fair way to sample is to take a number of shovels of coal from various points in the car as delivered, in such manner as to secure a representative portion of the coal from top to bottom and from end to end.

The effect of the purchase of coal by the Government under specification has been most satisfactory to all parties, resulting in the delivery of the highest product; one containing less ash and moisture and more B. T. U. An equitable basis for the settlement of any doubt on the part of the contractor or the purchaser where there is any difference of opinion as to the quality of fuel delivered.

SOME REASONS FOR GOVERNMENT INVESTIGATION OF MINING.—It is becoming clear that some sort of public supervision of mining operations is essential, not only to prevent needless waste in methods of mining, but to protect the lives of the men employed.

In 1906, 2,061 miners were killed and 4,800 injured in the coal mines of the United States. In 1907 about 3,500 were killed, an increase in one year of nearly 60%. Since 1889 there have been killed in this country 26,340 miners. Europe, France and Belgium have death rate in mining as low as 1 per 1,000. In the United States for the same period the rate is 3.4 per 1,000, or over three times as many. The lower rate of fatalities in European countries is due to mining legislation for safeguarding the lives of persons and property; also to the establishment by the Government of testing stations for the study of problems relating to safety in min

... including the use of explosives. Belgium, which country the death rate is least, has the best thoroughly equipped testing station in the world.

The deaths from mine accidents in the United States in 1906 include 80 from powder explosions, 228 from gas and dust explosions, 1,008 from falls of roof and coal and 372 from other causes. Of these accidents 50% were the result of falls of roof, the ratio from this cause ranging as low as .4 per 1,000 in Belgium and ranging thence to 1.7 in 1,000 employed in the United States. Roof falls are due in large measure to the jarring and loosening effect exerted by discharges of large amounts of explosives, the actual fall of rock or coal often occurring months later, due to the weakened condition of the roofs and walls from improper use of explosives. In foreign countries restrictions in the maximum amounts of explosive used have greatly increased safety from explosions from gas and have materially diminished the accidents due to falls of roof.

Explosions of coal dust and fire damp, which resulted in 11% of deaths in coal mines in this country last year, are brought about chiefly by ignition from explosives and from the miners' lamps. A careful study of these causes at foreign testing stations has reduced loss of life from them to a minimum. For example, in 30 years in Belgium the deaths from this cause have diminished from .4 per 1,000 to .04 per 1,000, or to one-tenth of the original number. Other causes of fatal accidents are defective hoisting apparatus, suffocation by CO_2, etc., which may be materially controlled by state mine inspectors if a sufficient number of intelligent and capable inspectors were provided.

BRIQUETS.—Another important factor in conserving the coal supply is found in the manufacture of briquets. These are composed of waste bituminous or anthracite coal mixed with 6 or 7% of gas pitch, the whole pressed into cakes or briquets by machinery. Briquets have been used in foreign countries for many years with much success. There the coal supply is very limited and the people of Europe have been forced into the utilization of hitherto waste coal.

Briquets, in addition to affording a means of utilizing the waste coal, have a number of advantages over raw coal. They hold together until almost completely consumed, which gives the air a chance to get between them, making the combustion more perfect and their burning under favorable conditions almost smokeless. It has been demonstrated that they produce a hotter fire than coal because of the added fuel value in the pitch. They cost at present slightly more than lump coal, but it is believed that the increased efficiency more than covers the increased cost.

Many railroads have taken up experimentally the combustion of briquets because of the economy involved. The increased power derived from the use of briquetted coal is found to more than offset the cost of its production. Locomotives may use briquets while entering cities in order to diminish the amount of smoke, the briquets being practically smokeless when properly fired. The Pennsylvania, the Illinois Central, the Burlington, the Rock Island, the Missouri Pacific, the Chesapeake & Ohio, the Seaboard Air Line and the Atlantic Coast Line have been testing briquets manufactured by and in cooperation with the Geological Survey and all are pleased with the progress made.

In recent tests of New River coal briquets on the Chesapeake & Ohio Ry., the briquets ignited very freely, making an intensely hot fire. When the engine was working very little smoke was emitted. It was found that a very heavy fire could be carried, as there was no danger of clinkering, and comparatively little ashes left in the fire-box and ash-pan, or cinders in the front end, the entire briquet being consumed. When the briquets were used comparatively no cinders were thrown.

In tests of Pocahontas coal briquets on the Atlantic Coast Line R. R., 172,700 lbs. of run-of-mine coal were consumed in making 10,912 car miles, as against 161,980 lbs. of briquets in making 12,896 car-miles; the engine when burning coal made up 231 minutes lost time and when burning briquets, 292 minutes. The tests indicated that the briquets all burned up, leaving no dirty fire at the end of the trip, with a saving of 30 minutes time in hostling the engine. They did away with all the black smoke while using steam and a very little black smoke when the steam was shut off; this can be overcome by altering the air supply. The briquets did away with the stopping up of the flues and the use of slash bar.

Capital has entered upon the manufacture of this form of fuel even before the experiments now in progress by the United States Government have been completed. Briquetting plants have already been erected in New York, Pennsylvania, Virginia, North Dakota, Washington, Michigan and Missouri, and companies have been formed to erect plants in other States.

An impetus has been given to the briquet industry by the interest taken in this fuel by the navy. A series of important tests is now being conducted with indications of success. In tests on the torpedo boat "Biddle," where briquets were used in one boiler and raw coal in the other, less briquets were used and 25% more steam was produced.

Two or three strong reasons exist in favor of this fuel on war vessels. One is that, with proper furnace equipment, it makes little smoke and this is a very valuable point in war vessels. Bituminous coal leaves a streak of black cloud in the sky by which an enemy can know the exact location of the vessels. Another reason is that briquets are more easily fired and reduce boiler-room forces. The third is that they will evaporate more water for the same grate area and thus allow a greater power output from a given furnace and boiler.

One hundred and fifty tons of briquets, made by the Fuel-Testing Plant from bituminous coal, with 6% pitch binder, were tested on the battleship "Connecticut" in comparison with an equal amount of American anthracite culm which was briquetted in England. The briquets were roughly handled, five times in all, from the place of manufacture to the coal bunkers but showed comparatively less breakage than would have occurred with lump coal from the same mines.

The results indicated that less smoke was formed with the bituminous briquets than with the anthracite briquets or with run-of-mine bituminous coal. The percentage of ash was lower than with ordinary run of mine coal. The smoke made was one-half as dense as made from the same raw coal. The labor of firing was much less with briquets than with coal. Less draft was required with the briquets than with coal. Higher furnace temperatures were obtained with the briquets.

The low rate of combustion of the anthracite briquets made it impossible to force the boilers to their rated horsepower. The anthracite briquet, being made of culm, had a high percentage of ash thus gradually filling the furnace and reducing the steam pressure. The weight per cubic foot of bituminous briquets stored was about 8% less than run-of-mine coal, or about the same as lump coal; and the number of available heat units per cubic foot of space greater than run-of-mine coal, which means a greater steaming radius per ton of bituminous fuel.

Briquets appear to have the additional advantages of permitting the fires being kept up for long periods without cleaning, by giving a more uniform steam pressure, by requiring less sweeping of tubes and by no liability to spontaneous combustion and hence diminished insurance rates. More fuel can be burned per square foot of grate surface, the capacity of the same boiler being increased 20 to 40%. Steam pressure can be raised more rapidly.

WASHING AND COKING TESTS OF COAL.—In connection with the tests of coal under the steam boiler in the gas producer and for briquetting, the Geological Survey made 192 coking tests on 100 coals collected from 17 states. Of these tests 100 were made on raw coal and 92 on washed coal. All were made in regular beehive ovens, but of various diameters and height of arch. Some of these tests showed that with the addition of a small amount of pitch good coke could be produced from coal which, when tested raw, gave no coke or coke of inferior quality. Other tests showed that coal, which tested raw gave negative results, when tested after washing to the proper degree produced coke of good metallurgical quality. In addition to these coke tests of coal from all parts of the United States, a large number of tests have been made on coals received from the Rocky Mountain regions; and representative of those found in the Government-owned public lands. It was surprising to find that in all these tests, except three, good coke was produced by proper manipulation or prior washing.

At the washery of the Geological Survey, which is attached to the coke plant, 153 tests have been made on nearly as many coals from all parts of the United States. These tests showed an increase in moisture of 10% to 30% but they showed progressively, as the method of washing developed, a reduction in ash ranging from 20% to 60% and a reduction in sulphur of from 10% to 50%. These tests showed that coal which in a raw state was utterly unfit for steaming purposes could be made fairly good for such purposes by washing and that coals unsuited for coking can be made available in the same way.

The coals which were tested by washing and coking were afterwards subjected to cupola tests to determine the strength of the coke under the ordinary load which they may receive in a blast furnace. In all 170 such tests were made resulting in the accumulation of a vast amount of valuable data concerning the record of melt which, taken in connection with the indications of the series of coals tested and the analyses of the corresponding coke, furnish useful information as to the melting ratio of iron and coke, the rate of melting per hour and the amount of iron recovered.

PETROLEUM PRODUCTS, BENZOL AND DENATURED ALCOHOL.—The supply of gasoline, a distillate of petroleum, is so inadequate to meet the demand that the present price is as low as it is liable ever to fall. The producers of this fuel are anxious to see the substitution of kerosene and of crude petroleum encouraged as a relief to the demand. The Geological Survey has commenced a series of comparative tests on power production from gasoline, kerosene, benzol and denatured alcohol. The latter is far the most important in connection with the conservation of fuel resources. Being a vegetable product, the greater the demand the greater will be the supply. On the other hand, every gallon of mineral oil consumed is one gallon less in existence in the earth, while each gallon of alcohol consumed will encourage the growth of vegetable products from which it may be produced. Moreover, alcohol can be produced most cheaply in the tropic regions from sugar cane, cassava, yams, etc., where mineral fuels are least abundant and most expensive. Benzol, the substitute for gasoline most used in Europe, is derived chiefly from the by-product coking processes. Investigations into the by-product coking now being commenced by the Fuel-Testing Division may aid in the encouragement of the production of benzol and the saving of that much fuel now wasted in coking coal with the beehive oven.

A series of 2,300 comparative tests on two identical types of gasoline and alcohol engines of 15 HP., just completed at the Norfolk Fuel-Testing Plant, have shown one important result. Under most advantageous conditions for each type of engine and fuel, the average minimum fuel consumption was 0.8 pint per hr. per B. HP. for both alcohol and gasoline. Considering that the heat value of a gallon of denatured alcohol is only about 0.6 that of a gallon of gasoline, this result of equal fuel consumption by volume is significant. Commercial denatured alcohol (91 to 95% alcohol) was used with compression ranging from 150 to 180 lbs. per sq. in. gage. Whereas gasoline now sells at from 18 to 20 cents per gal., with little likelihood of becoming cheaper, denatured alcohol has al-

ready fallen from above $1 per gal. to about 35 cents. It seems, therefore, not improbable that with increasing demand and better legislative encouragement alcohol may ere long undersell gasoline, over which it has numerous advantages, including less liability to explosion, smaller fire risk, no odor, etc.

THE RELATION OF THE ENGINEER TO THE CONSERVATION OF NATURAL RESOURCES.*

By WILLARD A. SMITH.†

The world is constantly bidding higher for men of great ability and thorough training. Especially is this true of our own country and of the combination of the engineer and the man of affairs.

Engineering has had many definitions—most of which qualify and enlarge rather than actually define. In a very real sense we may speak of it as the science of economy, of conserving the energy, kinetic and potential, provided and stored up by nature for the use of man. It is the business of engineering to utilize this energy to the best advantage—so that there may be the least possible waste. Nature has stored up combustibles in the shape of coal, oil and wood, the force of gravity in running or elevated water, the force of the wind, solar radiation, tidal power, and animal or muscular energy. These are the materials of engineering, to utilize which to the best advantage calls for the best preparation possible for the engineer to attain.

With the lavishness of newness, little recking our rate of development and its terrible destructiveness, we have gone on in this country along the lines of least resistance until the end of some of these resources is almost in sight. The President has called a conference of Governors of States to consider what can be done towards conserving the coal deposits, the forests and the water supply, all of which are disappearing with startling rapidity. The common weal calls for engineers prepared to meet the situation; for men who shall know how to make every possible unit of energy useful by improved machinery and methods; who can substitute other sources of energy for those which are vanishing; and who can plan and organize a general policy looking to the largest immediate returns without sacrificing the future of the race.

Our country calls for such men and they are needed in the councils of the nation. The business man has broken into the preserves of the lawyers in legislative halls and administrative offices. Why should not the "live-wire" engineer be there also? Why should he not be a maker of policies, instead of a mere technician, retained to work disadvantageously under the direction of the incompetent?

We sadly need in public affairs some of these qualities which he must possess and cultivate. The engineer must be an accurate man; he must know his data and his formulas; and his calculations must be exact. He is needed in politics to combat its dishonesty and slouchiness of thought and method. The engineer must be honest with himself—a kind of honesty all too rare. These qualities fit him rarely for the consideration of problems of national import which are not usually considered as engineering.

The engineer's habits of thought, carried into political economy, may make of it a higher grade of engineering. Albert Fink, the great civil engineer, spent his maturest years in organizing and directing the railway traffic associations of the country, eliminating waste and dishonesty and endeavoring so to unify the great volume of transportation that it might give the public the best service at the lowest cost, and yet permit railways to make such earnings as to insure further development. In this work, he often told me, he was still the engineer. He had graduated from one life class to another, finally reaching, as he deemed it, the highest field of engineering.

Such an engineer will not be content with simply estimating the construction possibilities of any proposed physical development. He will examine into the actual necessities for it and the probabilities of adequate return; considering that the public money should not be sunk merely for the benefit of speculators and contractors or to promote the fad of a class of engineers.

For instance, there is now before the country a proposition for the investment of enormous sums in the improvement of waterways. These are advocated by three classes—men having an itch for figuring in the public eye, politicians seeking an issue to justify their existence, and engineers interested in the technical features of the proposed work. So far as I can see, there has been no careful investigation of the traffic which can possibly be developed; and in most cases it is not only now an unknown quantity, but the conditions for future development are utterly lacking. Ought not the ideal engineer to be an economist, who shall dare to say when engineering development ought not to be undertaken as well as when it ought?

*Extract from an address on "The Need of Graduate Courses in Engineering" delivered as a part of the Installation Exercises of Dr. W. F. M. Goss as Dean of the College of Engineering, University of Illinois, Feb. 5, 1908.

†President, Railway & Engineering Review, Manhattan Building, Chicago.

THE FAILURE OF AN OLD RAILWAY BRIDGE IN FRANCE.

One of the worst railway accidents which France has had to chronicle for some time was reported briefly in our issue of Aug. 8, 1907, p. 153. A passenger train crossing a bridge over the Loire near the city of Angers, on Sunday, Aug. 4, broke through the bridge floor and part of the train fell into the stream, 27 persons being killed. The circumstances of this accident appear to be remarkable, partly for the reason that the bridge was so old and of such inadequate strength as to make it a matter of wonder that it did not fail earlier. The bridge, was built in 1876, and appears to have been much overloaded by the train weights of recent years. The general style of construction, suggested by the view, Fig. 1 herewith, and the floor details, shown in the cross-section, Fig. 4, indicate clearly that it was light and old-fashioned. There is some reason for believing, however, that the failure did not result from mere weakness, but was brought about directly by derailment of the train, or rather the impact of the train after the latter had been derailed just back of the bridge. Be this as it may, the bridge clearly had outlived its usefulness, and was a menace to safety. Yet there appears to have been no previous warning of this by the maintenance or engineering officials of the railway.

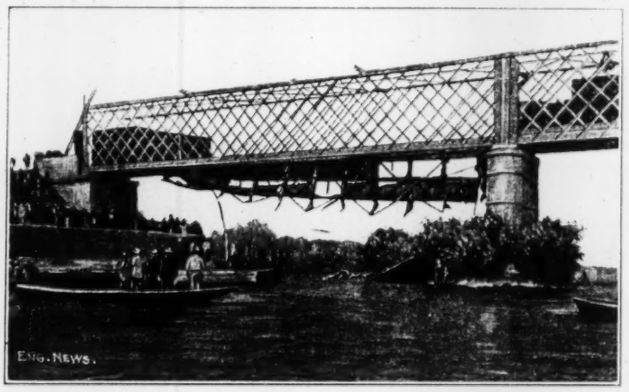


FIG. 1. VIEW OF THE WRECKED SPAN OF THE LOIRE BRIDGE, LOOKING UPSTREAM.

A description of the accident was given recently by Mr. Jean Phizey, in the "Génie Civil," and from this article we take our illustrations and data. Mr. Phizey states that two investigations of the accident were made, one by the organization of the French State Railways (on whose line the bridge is located) and the other by an expert commission at the instance of the local judiciary authorities; the commission consisted of three engineers, namely, Prof. Jean Résal, of the School of the Ponts et Chaussées, Mr. E. Pontzen, and Mr. Ménard. But the results of both investigations have been withheld from publication, it seems, so that Mr. Phizey's article is an independent statement of the circumstances and expresses his own views of the cause.

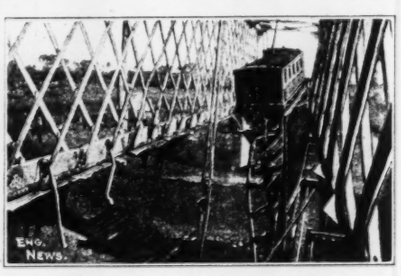


Fig. 2. View Along Broken Floor, Looking from First Pier Toward Abutment.
(Stream Flows from Right to Left.)

The bridge lies on the line between Angers and Poitiers and crosses the Loire at a point where an island divides the river into two branches. The crossing of the left-hand or main branch is the one concerned in the accident. This consists of seven spans of parallel-chord lattice construction, continuous over the intermediate supports, and resting on rollers everywhere except on the fourth river pier counting from the island abutment, where there is a fixed bearing. The shore span at either end is 130½ ft. long ... to center, while the five intermediate spans ... 158 ft. long c. to c. The bridge is single track.

The main trusses are spaced 14.9 ft. apart, c. ... c. They are braced by a full upper lateral system with cross struts, whose panel-length is about 20 ft., and a lower lateral system composed ... crossed diagonals using the floorbeams as struts. The floorbeams themselves are plate-girders resting on the outstanding leg of the L-shaped lower chord of the truss and connected to the vertical web of the chord by an angle connection containing five rivets. The floorbeams are spaced 9.... ft. apart c. to c. Two plate-girder stringers are framed into them, and on the stringers rest longitudinal wooden sleepers which carry the rails. Each sleeper is stiffened by a pair of side channels composed of two plates and four angles. Channels laid flat serve as spacers between the sleepers, being bolted to the angles of their side plating, and between the spacers are loop-rod ties similarly bolted to the sleeper plating. The space between the sleepers and between trusses and sleepers seems to have been covered by steel plate laid loose (not riveted) over the floorbeams and a transverse supporting angle midway between floorbeams.

Details of the makeup of the trusses are not given in our source, but it seems that the lattice was composed of single angles set very close, corresponding (about) to a six-intersection web system. Vertical angle stiffeners were placed at intervals of about 40 ft., and heavy stiffeners were provided over the piers to take the support reaction.

About a mile from the river, on the right bank, toward Angers, is the station of La Pyramide, and just across the river, on the left bank, is the station of Ponts-de-Cé. The alinement between the two is not quite straight, in particular the crossing of the main channel has a slight curve at either end, both curves being to the left when going from La Pyramide to Ponts-de-Cé.

The track consists of double-head rail in chairs, with metal keys. On the bridge the rail is in lengths of 72 ft. and the chairs are spaced 24 to 34 ins. apart. On the approaches and the adjoining sections of line, however, steel ties of the State pattern are used, spaced 26 to 40 ins. apart.

On the day of the accident, Aug. 4, 1907, a passenger train leaving Angers at 11.25 a. m. reached the bridge at 11.45. It consisted of a locomotive and tender followed by a baggage car, four 3d class coaches, one 1st class coach, two 2d class coaches and a caboose. The train was well filled. It crossed the smaller channel of the Loire and the island in safety, and entered upon the bridge over the main channel. The locomotive had just reached the first pier when the whole floor of the first span tore loose from the downstream or right-hand truss and dropped the front part of the train into the river. The locomotive, tender, baggage-car and first

coach went down; the second coach hung over the abutment but did not fall. Engineer, conductor and 25 passengers were killed, while the fireman was able to swim to shore.

The appearance of the bridge is well shown by the three views, Figs. 1 to 3, reproduced herewith. The floorbeams are torn away from the downstream truss along the whole length of the first span, and hang downward from the left-hand truss. Mr. Phizey states that the latter truss is somewhat warped and its lattice web is bellied out, evidently a result of the twisting action of the floor in swinging down.

The attachment between floor-beams and down-stream truss failed in the rivets in some cases, but more often the attaching angles broke along the root of the angle. As may be seen from the views, the outstanding leg of the chord was in many cases sheared or punched out by the end of the floorbeam. The details and dimensions of the connection, size of rivets, etc., are not given by Mr. Phizey, except by the cross-section reproduced here as Fig. 4, and the statement that there were five rivets in the connection. As far as can be judged, however, the connection was excessively weak, and its failure is not surprising. The train was light, however, having an engine weighing only 45 tons, and the total train weight being only about 115-120 tons, giving an average load of 2,000 lbs. per foot of track. The test train prescribed by ministerial order of 1891 for new bridge consists of two 60-ton locomotives with 28-ton tenders, followed by a continuous length of 18-ton cars, giving an average load of 3,000 to 3,200 lbs. per foot of track. These are remarkably low loads when compared with American railway practice.

FIG. 3. A CLOSER VIEW OF THE BROKEN FLOOR FROM BELOW.

Mr. Phizey describes marks on the ties and rails some 30 ft. back of the entrance of the bridge which he interprets as showing that the train was derailed before it reached the bridge. He concludes that the locomotive was off the rails when it entered the bridge, and ran over the floor plating, bumping over the floorbeams. Marks on the bridge portal and along the web lattice confirm him in this belief, and he concludes that when the locomotive struck the pier a greater shock than before was given to the structure and the floorbeams tore loose.

Going further into the matter of the derailment, the author notes that no rail expansion

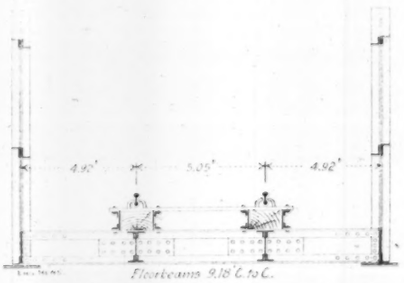


Fig. 4. Part Cross-Section of the Loire Bridge.

devices were provided between the bridge and approach rail. He calculates that the expansion of the bridge rail would be sufficient to throw the curve at the end of the bridge and probably to crowd the gage at the curve, which condition would tend to produce a derailment. Trouble from rail expansion had previously been experienced at the other end of the bridge, where the ends of some chair keys were sheared off by the rail.

The bridge had no guard-rails either outside or inside. Their recognized necessity is illuminated not only by the accident described but by an earlier accident, in 1893, when a derailed train on this same bridge, while going from Poitiers to Angers, tore out some of the web lattice and did considerable damage to the floor. It is not stated whether the same or another span was involved in that accident; the damage was repaired but nothing was done to protect the structure against a repetition of the accident.

CUTTING A HOLE THROUGH A CONCRETE DAM WITH AN AIR PLUG DRILL AND CHISELS.

By ERNEST W. SCHODER,* Assoc. M. Am. Soc. C. E.

An interesting piece of concrete cutting by means of 1½-in. flat chisels used with a compressed air plug drill was performed at Ithaca, N. Y., during the summer of 1907. There appear to be few records of the rate of such work, particularly when done by chipping as in this case.

The problem was to cut through a ten-year old concrete dam a circular hole for a flood wasteway at the upstream end of which it was intended to place a 60-in. sluice gate. The dam is on Fall Creek and forms the 20-acre reservoir utilized by the hydraulic laboratory and by the hydro-electric power plant of Cornell University. It was described in Engineering News of March 2, 1899.

The stone in the concrete is crushed shale, and the cement used a mixture of Rosendale and Portland. The concrete seemed to be soft and tough rather than hard and brittle. On account of the difficulty of drilling holes in concrete of this texture the plug and feather method was not feasible, and with the air drill the rapid action of the tool made it almost impossible to prevent it from sticking. Chipping by 1-in. flat chisels did not work satisfactorily, but the wider 1½-in. chisels seemed to be suited to the material.

The thickness of the dam is 16 ft. where the hole was cut, the invert being 2½ ft. above the rock creek bottom. The hole is 5½ ft. in diameter for the downstream 13 ft. of its length, and 6 ft. in diameter for the last 3 ft. near the upstream face of the dam.

The hole was cut at an average rate of exactly 1 ft. per day of nine hours, using a single drill with air at 70 lbs. pressure. Two Italian laborers alternated in holding the drill. A liberal supply of sharp chisels was kept ready so that there was no delay. The chisels were sunk into the concrete until the repeated blows of the plug drill hammer caused a piece to break out. A few seconds to five or ten minutes were necessary to break out a piece of the concrete. As the men became accustomed to the drill they used at times a wedging method by sinking two or three chisels into the concrete along a line calculated to loosen a large piece containing perhaps ½ cu. ft. of material. This worked well, especially when the lower portion of the hole was advanced ahead of the upper portion. No water leaks were encountered. When the cutting approached within 1 ft. of the face of the dam, the reservoir was emptied through the laboratory canal.

The work was done under the direction of Prof. E. E. Haskell, M. Am. Soc. C. E., Director of the College of Civil Engineering of Cornell University.

*Assistant Professor of Experimental Hydraulics, Cornell University, Ithaca, N. Y.

STEAM TURBINE DEVELOPMENT in this country is indicated by the accompanying tables arranged from data furnished by the two large manufacturers of this apparatus. There is of course a considerable amount of business by all the other makers, which is not shown here. Owing to the different ways in which the data contained in these two tables has been classified by the turbine makers it has been impossible to tabulate them for more direct comparison or combination.

TABLE I.—SUMMARY OF WESTINGHOUSE-PARSONS TURBINE DEVELOPMENT. (Including all plants shipped or on order up to Dec. 31, 1907.)

	Total Number of Plants.	Total KW. Capacity.	Average Turbine KW.
Light Electric Traction	69	282,600	1,975
Electric Lighting—			
Central Stations	73	180,100	1,440
Isolated Plants	7	3,200	400
Municipal Plants	11	570	8,700
Steam R. R. Electrification	4	46,900	3,350
Industrial	81	76,300	603
Mining and Irrigation	19	21,950	686
U. S. Government	4	12,250	1,225
Miscellaneous	14	483	8,700
Total	282	640,700*	....

*Of this figure 99,250 KW. was in plants below 1,000 KW. capacity and 223,400 KW. was in plants of more than 10,000 KW. capacity. Business uncompleted Dec. 31, 1907, 60 turbines of 153,550 KW. total, leaving shipped or in operation 433 machines of 487,150 KW. total, or of 1,122 KW. average.

TABLE II.—SUMMARY OF CURTIS TURBINE DEVELOPMENT (including all orders to Dec. 31, 1907.)

	Total Number of Plants.	Total KW. Capacity.	Average KW. Plant Capacity.
Central Station and Railway Traction Plants	261	986,020	3,728
Industrial and Miscellaneous Plants	288	87,675	305
Totals	549*	1,073,695	1,956

	Number of Machines.	Average KW. Capacity per Machine	Total KW. Capacity.
Installations to Dec. 31, 1907.	943	857	807,610
Orders on Hand Dec. 31, 1907.	153	1,739	266,085
Total Sales to Dec. 31, 1907.	1,096	980	1,073,695
Orders for fiscal year ending Feb. 1, 1908	325	881	286,320

*Of this number 314 plants had a capacity of 1,000 KW. and less and 235 were above 1,000 KW.

AN ELECTRIC MINE-HOIST with novel features was recently completed by the Vulcan Iron Works of Wilkes-Barre, Pa., for the Hallidie Machinery Co., Seattle, Wash. There are two drums each with a winding capacity for 1,500 ft. of 1⅛-in. wire rope in three layers. Both drums are carried on a single shaft; one is keyed direct and the other runs loose driven by a jaw clutch operated by a hand lever on the operator's platform. The drum shaft is carried on three babbit-lined pedestals cast in the bed plate which also has cast on it similar bearings for the motor shaft. Between the drums is the main spur gear. The motors, Westinghouse, railway, 550-volt, 110-HP. type, are both mounted on a single shaft with a central driving pinion between and are controlled by a railway controller having eight points forward and eight reverse. The field frames of the motors are secured to the bed plate by nose-spring suspensions. At the end of each drum is secured an asbestos lagged brake ring—this type of brake being able to withstand the heat of the heavy braking.

HIPPODROME BUILDING AT CLEVELAND, OHIO.

By JAMES A. JOYCE.*

The building of the Cleveland Hippodrome Company, extending from Euclid Ave. through to Prospect Ave., a short distance west of East 9th St., Cleveland, Ohio, is made up of two office structures and a theater, as shown by the first-floor plan reproduced in Fig. 1, herewith. The office structures face Euclid and Prospect Aves., while the theater proper is situated between and forms an L with both of these buildings. The structure on Euclid Ave. is 11 stories high, and has a frontage of 100 ft. with a depth of 145.3 ft. The structure on Prospect Ave. is 7 stories high, and has a frontage of 56.66 ft., with a depth of 153.41 ft., and the theater extends 130 ft. along the main western line of the building and projects 200.3 ft. to East 8th place. Entrance is gained to the theater through the main corridor of either the Euclid Ave. or Prospect Ave. buildings.

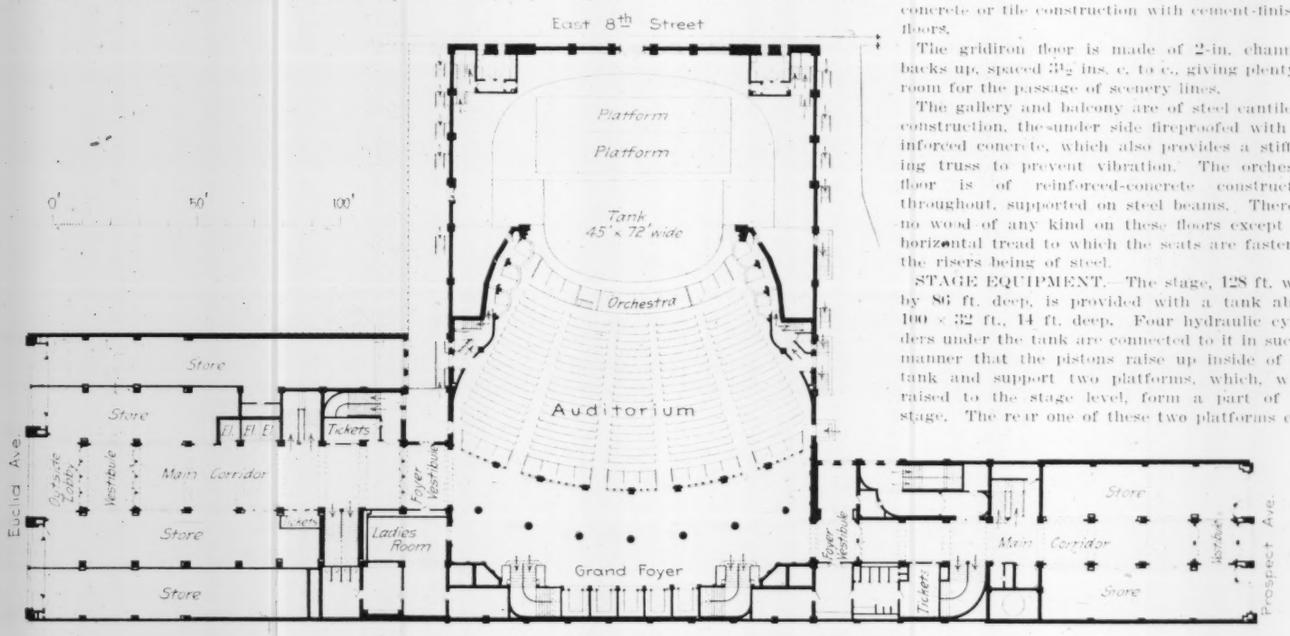


FIG. 1. FIRST FLOOR PLAN, CLEVELAND HIPPODROME BUILDING.

FOUNDATIONS.—Along the west side of the building, from Euclid Ave. to Prospect Ave., 428 ft., a large building adjoins the entire distance. This had to be under-pinned from 4 to 12 ft. The east side of the building for 150 ft. from the front of each street had to be under-pinned in a similar manner, but here the buildings were old, and the work of under pinning involved considerable difficulty.

A concrete retaining wall, reinforced with deformed bars, was constructed along much of the exterior, below ground level. The total length of this wall was 500 ft., varying in height from 18 to 27 ft. After the retaining wall was put in it was carefully watched, especially one 152-ft. section along which all of the structural material coming to the building was unloaded. Weekly instrument readings, however, failed to show any movement at the top of the wall. Elevations on the surrounding buildings were observed frequently, and photographs of the walls of the buildings being under-pinned were taken both before work started (to show their condition) and after the work was completed. The construction was accomplished without any settlement or movement.

A very difficult piece of foundation work was the sinking of eight cylinder pits, which were of reinforced concrete and extended down about 12 ft. into quicksand. Unfortunately this work had to be done after the columns supporting the proscenium arch were put in and were carrying their full load; these columns were only about 15 ft. from the location of the deepest pits. Steel sheet-piling was driven in circular rings, extending 12 ft. below the elevation of bottom of pits, with the expectation of keeping the sand from rising in the bottom. After beginning to excavate it was found necessary to allow the pits to fill up with water, then drive 1½ in. pipe down to below the bottom of the finished pits and pump in liquid cement to shut off the water and sand from the pits. In two or three cases the steel sheet-piling leaked to such an extent that it became necessary to allow the excavation to fill with water and then inject cement grout outside of the sheet-piling to stop the inflow. After excavation, the concrete bottoms were put in and the holes allowed to fill with water until the concrete took its initial set; then the pits were pumped out, inside forms put in, and the pits filled with concrete to the elevation supporting the cylinder guides.

BUILDING DETAILS.—The building is of steel frame construction, the most important portion being the auditorium. The framing of the office-building sections does not depart materially from the common type of tier building steel work.

The auditorium in front of the proscenium arch is roofed by trusses crossing the entire width of the building, and is ceiled inside with tile supported on steel tees.

The stage floor is of I beam construction, over which is laid 3 in. shiplap pine plank covered with 1⅛-in. flooring. This is the only wood on the entire stage; the other parts of the stage, dressing and rehearsal rooms are of reinforced concrete or tile construction with cement-finished floors.

The gridiron floor is made of 2-in. channels, backs up, spaced 3½ ins. c. to c., giving plenty of room for the passage of scenery lines.

The gallery and balcony are of steel cantilever construction, the under side fireproofed with reinforced concrete, which also provides a stiffening truss to prevent vibration. The orchestra floor is of reinforced-concrete construction throughout, supported on steel beams. There is no wood of any kind on these floors except the horizontal tread to which the seats are fastened, the risers being of steel.

STAGE EQUIPMENT.—The stage, 128 ft. wide by 86 ft. deep, is provided with a tank about 100 × 32 ft., 14 ft. deep. Four hydraulic cylinders under the tank are connected to it in such a manner that the pistons raise up inside of the tank and support two platforms, which, when raised to the stage level, form a part of the stage. The rear one of these two platforms controls two hinged platforms, one on either side, which, when the main platform is submerged, form inclines leading into the tank from either side. The entire stage over the tank can be lowered so as to give 10 ft. depth of water above the platform when fully submerged and show a water surface 100 ft. across the stage and 32 ft. in the opposite direction.

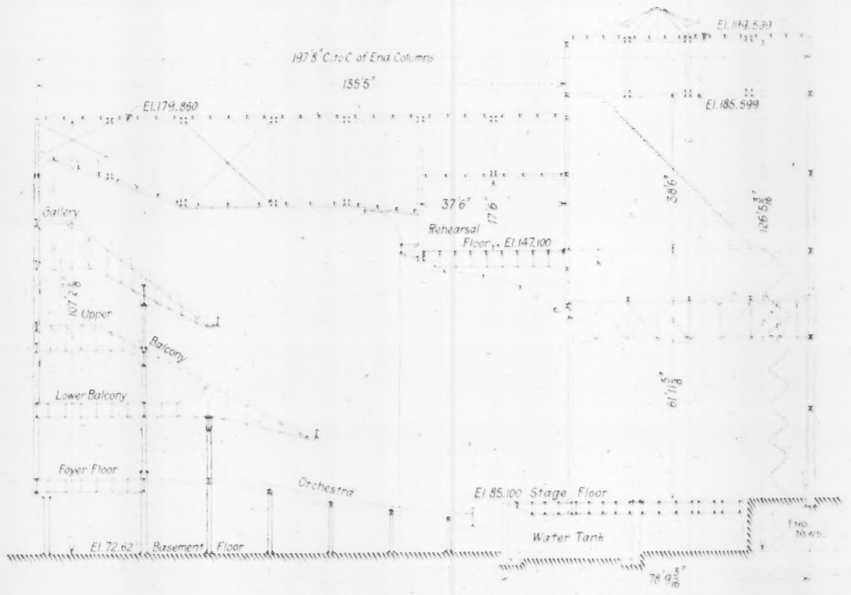


FIG. 2. LONGITUDINAL SECTION THROUGH THEATER, CLEVELAND HIPPODROME BUILDING.

The platforms in the tank are provided with automatic indicating devices which show the operator the depth to which the platforms are lowered into the water, thus helping to avoid accidents if the platform should not lower or any hitch occur in the operating machinery. The tank is also provided with glass openings through which light is thrown to illuminate the tank. The

*Chief Engineer, Cowing Engineering Co., Cleveland, Ohio.

platforms in the tank can be raised above the stage level 4 ft.

Back of the tank there are two additional platforms supported each on two hydraulic jacks. These can be raised 14 ft. above stage floor, and serve to facilitate complicated stage settings.

The pistons are 15 ins. in diameter and are guided in bronze bushed cast-steel guides at the top of the cylinder as shown in Fig. 5, which method obviates the necessity of boring out the cast iron cylinders. The cast-steel guides had to be made especially strong, as in some cases the piston extends up 24 ft. above the guides, while on the opposite end of the same platform the piston may only project 10 ft., thus setting the platform at a very steep angle. The water pressure required for operating the platforms will vary from 350 to 750 lbs. per sq. in., which is supplied by pumping direct to the cylinders, without using an accumulator. The cylinders are controlled by a 2½-in. lock valve and two 1½-in. three-way valves, so arranged that one pipe controls each cylinder, water being discharged through the three-way valve to lower. Fig. 5 shows the hinge support of the platform beams on the top of the piston. This provides for the change in length due to inclination of the stage platforms. The speed at which the platforms are to be raised is 10 ft. per min.

The proscenium arch opening being 76 ft. wide made it necessary for the flies, drapes, etc., to be about 80 ft. long; it was therefore decided to handle these parts by electric motors, automatically controlled to stop and start. Thus, when the stage is set and trimmed, it simply requires the throwing of a small double-pole double-throw switch to either raise or lower a piece, the automatic stop arresting it at either its highest point or at the point where it is set to stop. A semi-circular panorama forming the back drop is controlled in the same manner, except that it is counterweighted. Two electric winches are located under the stage, with wire cable extending up through swivel blocks to assist in handling large pieces on the stage floor and pulling pieces from the basement. These motors are controlled from the stage floor.

Back of the boxes on either side is a runway extending to the basement for use in bringing animals from their quarters in the basement to the stage floor. Over the proscenium arch a rehearsal room is provided 40 × 130 ft. and 18 ft. high.

FIRE PROTECTION.—A 17 in. brick fire wall separates the auditorium from the stage. The fire curtain consists of a steel frame covered with transite asbestos. This material stood the test of being heated to 2,000° F. and then dashed into cold water, without appreciable effect. The curtain, weighing complete 20,000 lbs., is counterweighted; it is controlled from the fly gallery by electric motor. It has upper and lower automatic

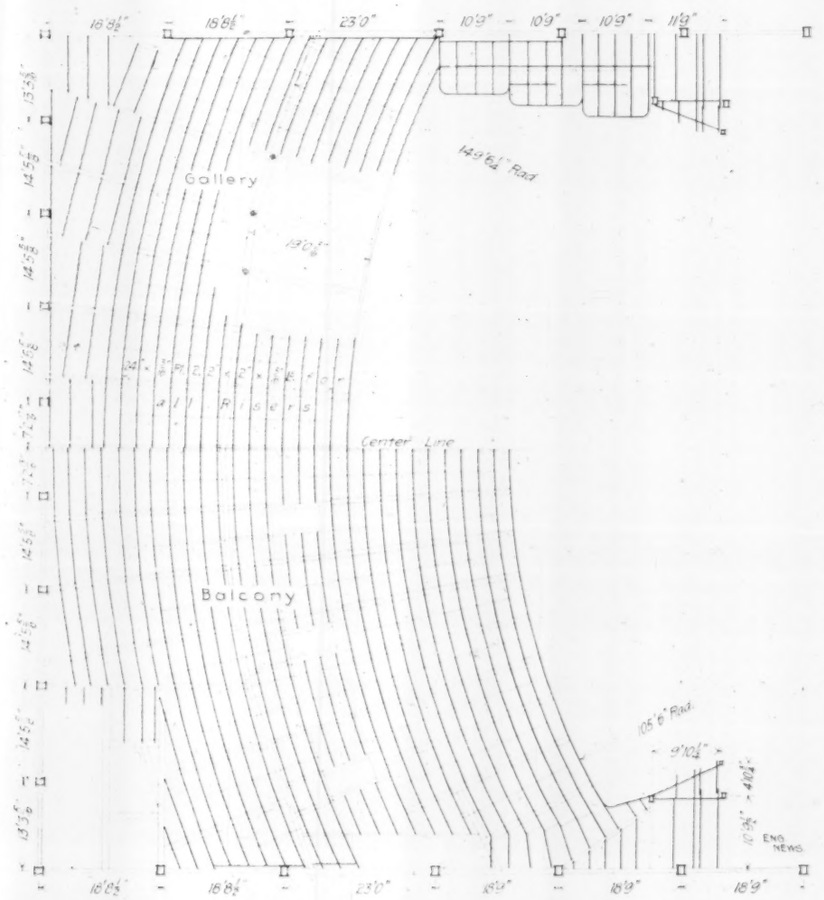


FIG. 3. PLAN OF FRAMING OF GALLERY AND BALCONY, CLEVELAND HIPPODROME BUILDING.

stops, and is so arranged that it can be lowered from either fire-exit on the stage floor.

The automatic ventilator over the stage, which opens in case of fire on the stage, has an effective area equal to about one-eighth of the entire stage. Its doors are of steel and can be opened from the stage floor at the fire-exit.

There is a very elaborate system of fire-escapes on the auditorium portion of the building, which provides a separate stairway on each side for the gallery, upper and lower balconies and the first floor. The theatre is provided with every known means for protecting its patrons against fire.

The building was opened to the public Dec. 30, 1907. Construction was begun in 1906. Knox & Elliott, of Cleveland, were the architects. The engineering design was worked out by The Cowing Engineering Company. Their work included the steel frame, foundations, fireproofing, hydraulic stage work, and much of the electrical operating machinery. The Cowing Engineering Company also erected the building.

A REPORT ON WATER AND SEWAGE PURIFICATION PLANTS IN OHIO.

For some years past the State of Ohio has been forging to the front in matters relating to the protection of public health. Its first notable step in this direction was made in 1893, when the Legislature passed an act requiring all plans for public water supply or sewerage systems, whether to be constructed by municipalities, companies or individuals, to be approved by the State Board of Health before work was begun. In the 14 years that have elapsed since that time, the Board has passed on 585 plans for new water works or sewerage systems or for changes or extensions in existing systems. In 1897 the Board began a five-year study of the sanitary condition of the streams of Ohio. The results of these investigations were published in five special reports making up a total of 1,229 pages.

The work of the Board in approving plans for water and sewerage systems, and in making sanitary investigations of the streams of the state, revealed the necessity of enlarged work to the end that the municipalities and companies submitting plans for approval should be subjected to supervision in order that the plans submitted might be actually carried out, and that when the works were built in accordance with the plans they should be properly operated. No means have yet been provided for the control by the State Board of Health of works while under construction and after being put in operation, but in 1906 the Legislature directed the State Board of Health to make an investigation of the "construction, the methods of operation and the efficiency of all" the water and sewage purification works of the state, both those serving municipalities and public institutions. A sum of $15,000 was appropriated for the purpose, and the Board was required to complete the investigation by March 1, 1908.* A partial report on the investigation, conducted under the requirements of this act, was recently submitted to the Legislature. The general supervision of the engineering work was entrusted to Mr. R. Winthrop Pratt, Chief Engineer of the Board. Mr. Philip Burgess, of Cincinnati, was employed as Special Assistant Engineer to examine water purification plants, and Mr. A. Elliott Kimberly, of Columbus, to take up sewage purification plants in like manner. Some of the analytical work was done in the field by the assistant engineers and some in the laboratory of the Board, the latter under the direction of Dr. Elmer G. Horton and later of Mr. L. V. Parker. The whole investigation was in charge of Dr. C. O. Probst, Secretary and Executive Officer of the Board.

The partial report just published consists of a general review of the investigations by Dr. Probst and of a general report by Mr. Pratt. These reports will be supplemented by detailed reports by the assistant engineers.

Dr. Probst states that the investigations of the Ohio streams previously mentioned led the Board to conclude "that no stream in Ohio was of sufficient purity, or could be so safeguarded against contamination, as to afford at all times a safe public water supply. The only exception might be the upper reaches of a few streams where small drainage areas affording enough water for small cities could, by careful policing, be kept free from contamination." Dr. Probst also states that the main objects of the investigation were to discover what water and sewage purification plants were inefficient; the cause of such inefficiency; methods of improvement; cost items, and, in addition, to interest local authorities in making necessary changes in construction and operation of their works. He further states that [when left to themselves.—Ed.] municipalities are, as a rule, reluctant to spend sufficient money to properly construct sewage disposal plants and that once constructed little interest is taken in their operation. Sewage purification plants, the investigation has shown, "as ordinarily constructed and operated" give small protection to public water supplies taken from lakes or streams into which they discharge. Fur-

*For a general review of the work of the Ohio State Board of Health on water supply and sewage disposal and stream pollution, see Eng. News, June 20, 1907.

ther studies of both water and sewage purification plants are needed, particularly in the use of coagulants in connection with mechanical filtration. In conclusion Dr. Probst submits, on behalf of the Board, four recommendations, as follows:

(1) That further studies be made of the water and sewage purification plants of the State, and of the general subject of water and sewage purification as it relates to Ohio conditions.

(2) That a special investigation and report be made upon each of the public water supplies of the State of surface origin where filtration works have not been introduced.

(3) That this investigation should include a study of all streams and lakes used or available for public water supplies, which are receiving sewage, to determine the degree and extent of pollution from this cause.

(4) That the State Board of Health be enabled to provide for the general supervision and frequent inspection, during construction, of all water works, sewerage systems, and water and sewage purification plants, so that any deviation from the plans as approved by the Board, that would materially lessen their efficiency from a health standpoint may be prevented.

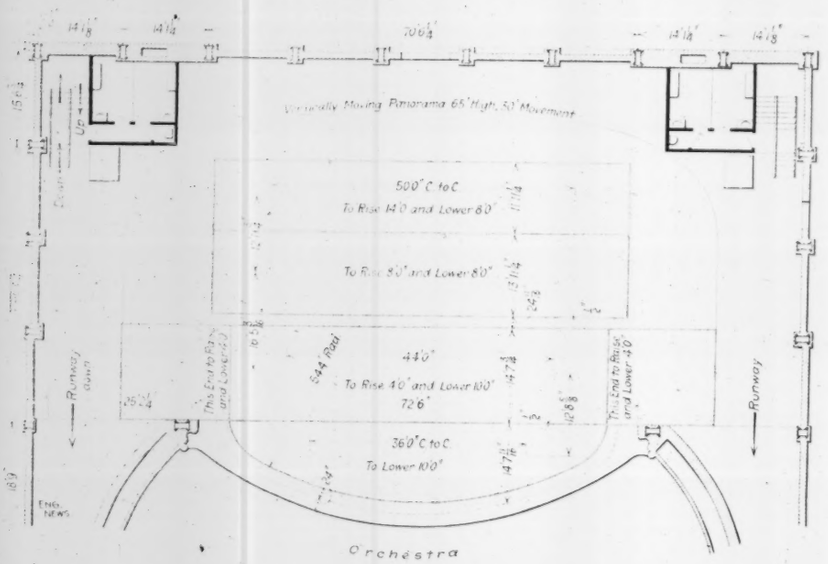


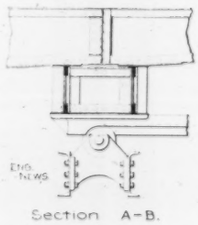
FIG. 4. PLAN OF MOVABLE PLATFORMS.

WATER PURIFICATION PLANTS.—The remainder of this article will be devoted to portions of Mr. Pratt's report. About 70% of the population enjoying public water supplies in Ohio now draw water from surface sources, for which water purification is considered necessary. At present 27 municipalities have water purification plants in use or under construction (see Table I.). These places have a combined population of 1,071,000, which is 50% of the population living in cities and incorporated villages. With two exceptions mechanical filtration is, or will be, in use by all of the 27 municipalities. At Columbus and Oberlin softening processes are included. The plant at Ironton, which is included in the 27 municipalities, will employ, when completed, "a system of natural filtration with intention of obtaining water from sandbars beneath the Ohio River."

During the investigation detailed examinations were made of 20 water filtration plants. These plants were subjected to observation for periods of from one to five days, on an average of four different visits. Many samples of water were collected for determination. The observation showed, in particular, that at many of the works a very poor quality of alum was being used at the beginning of the investigations.

Of 19 water purification plants studied, there were 12 which at the beginning of the investigation were not producing safe water. During the investigation the number of plants yielding unsafe water was reduced to 8, and the conditions affecting the operation of the 8 plants were greatly improved. At the outset it was found that some of the operators of filter plants "knew nothing about the principles related to efficiency from a sanitary standpoint." One of the results of the investigation has been to show local authorities how the operation of the plants could be reduced in cost, as well as increased in efficiency. Mr. Pratt states that local officials have generally been "glad to receive advice from and to cooperate with the State Board of Health."

The need of preliminary studies before deciding on what coagulant shall be used has been made apparent. It has been found that where copperas and lime are used more skill is required on the part of the operator than where alum is employed as a coagulant. It has also been found that copperas and lime require larger quantities of wash water than does alum. The need for giving some attention to the design of coagulating basins has been made apparent by the studies. The minimum size of a coagulating basin, from a hygienic standpoint, is two hours capacity, while for economical operation four to six hours capacity is none too large. The need for larger filtered water basins has also been shown.



Section A-B.

Broadly speaking, the cost of mechanical filtration has been found to range from $3.50 to $7 per 1,000,000 gals., or 20 to 40 cts. per capita per year, these figures including interest charges.

Mr. Pratt states that while cities as a rule keep accurate death records, the case records of typhoid fever are "difficult to obtain from the local officials." In making the Youngstown typhoid investigation (See Eng. News, Jan. 10, 1907) the assistant engineer in charge was obliged to make first-hand inquiries as to typhoid cases.

SEWAGE PURIFICATION PLANTS.—Beginning with the chemical precipitation plant at Canton, established in 1893, there were in Ohio in 1898 seven sewage purification plants owned by municipalities or by public institutions. At the present time 46 plants have been built, or are under construction, equally divided in number between municipalities and institutions. (See Table II.) The population tributary to these 46 plants is about 270,000, which is 12% of the urban population of the state. In partial explanation of the far greater percentage of the population served by water purification than by sewage purification plants, Mr. Pratt says that the larger cities of the State had built their main sewer outlets before the State Board of Health was given jurisdiction over sewerage plans. In addition to the 46 plants already built or under construction, plans for some 50 plants have been approved by the State Board of Health, and it is expected that construction will soon be begun under these plans. Table III. shows the number and character of the various sewage purification systems in existence or under construction in December, 1907.

During the investigation 35 of the sewage purification plants in operation were visited from one to eight times, the largest plants having been visited at least seven times. Samples of sewage were collected and analyses made. When the investigation was begun some two-thirds of the sewage purification plants, including most of the larger ones, were found defective in either design or operation, or both. Municipal officials then showed "little interest in sewage purification, because it is a matter which benefits their neighbors down stream rather than themselves." Further reason for lack of interest was that most of the plants have been built at the instance of complainants below the sewer outlets and therefore have been made as small and as cheap as possible and have been turned over to unskilled attendants for operation. At the close of the investigation 22 plants were classed as satisfactory; that is, they prevented a nuisance in streams receiving sewage; but 13 plants were not satisfactory. The chief reasons for failure were given as "ignorance and carelessness in operation, and even absolute neglect, together with outgrown plants."

Under the sub-heading "Comparison of Methods," Mr. Pratt's report may be quoted from as follows:

Viewing the matter solely from the standpoint of preventing offensive pollution of the streams of the State, that is, from the standpoint of producing a non-putrescible effluent, the investigation has shown that intermittent filtration through sand or other fine material, such as crushed coke or cinders, is the most satisfactory method. Of the 22 plants which at the end of the investigation were producing a satisfactory effluent, 17 employ this type of filtration. From another standpoint, out of 19 sand filtration plants (using this as a general term for filters of fine material), 17 were satisfactory; of 16 plants of other types, such as contact filters, miscellaneous coarse-grain filters, septic tanks alone, and chemical precipitation, only 5 were satisfactory. It is true that the 17 fine-grain plants include several small institutional plants, but the sewage from these is generally quite as difficult to treat, at a given rate, as is municipal sewage.

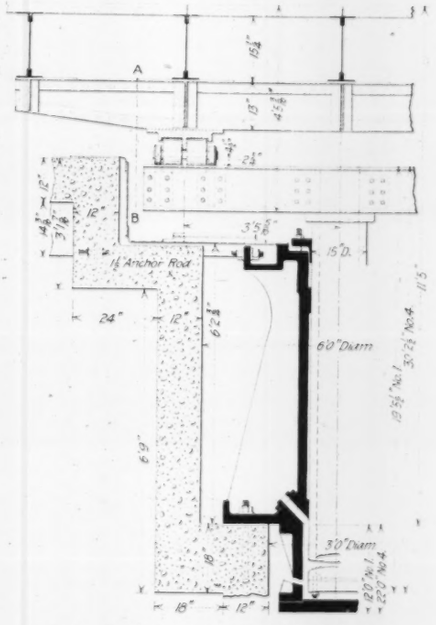


FIG. 5. DETAILS OF HYDRAULIC JACKS.

The fine-grain filters have in many cases purified the sewage considerably beyond the non-putrescible limit and to a degree which could not be expected with any of the other methods. On the other hand, two or three of the contact filter plants have produced effluents which have entirely fulfilled the requirements of local condi-

tions and which have been sufficiently satisfactory. While, therefore, filtration through sand or other fine material has served to better protect the streams of Ohio and gives better bacterial purification than other methods, yet where the cost places this method beyond the means of the municipality (as is usually the case with the larger plants), and where a high degree of purification is not necessary, coarse grain filters, if amply and correctly designed, may be installed with safety.

FIG. 6. VIEW IN BALCONY, SHOWING CONSTRUCTION OF GALLERY CANTILEVERS, CLEVELAND HIPPODROME BUILDING.

In regard to odors from sewage plants, considered independently from the character of the effluent produced, our investigations have shown that this feature has not been an important one and that with a well-designed plant it can be controlled by intelligent management. The degree of offensiveness of odors and the distance penetrated by them are largely affected by the condition of the atmosphere. Odors more or less objectionable may arise from scum or from freshly deposited sludge, when the latter is exposed to the air, as is done when septic or settling tanks are cleaned. This usually affords no cause for complaint, however. Odors may be caused by the aeration of septic sewage, if the latter has been retained too long in the tanks. No odors need be caused from the filters, whether they be of sand or other material, if the sewage is applied intermittently in suitably proportioned doses and the surfaces of the filters are kept reasonably clean.

Mr. Pratt recommends that septic tanks be divided so that during periods of heavy gas formation, accompanied by the heaving of sludge to the surface of the tank, the troublesome unit may be cut out of service. Periods between cleanings of septic tanks, the investigation has shown, vary from "a few months to four years or more, depending on the character of the sewage and size and design of tank." Under normal conditions it does not seem to be necessary to cover septic tanks unless they are particularly near to highways or other public places, but covers have the advantage, especially in the coldest parts of the state, of maintaining a more even temperature in the tank throughout the year. Subsequent rates of treatment are no higher with septic effluents than with effluents from sedimentation tanks. Under ordinary conditions septic tanks with a holding capacity of 8 to 12 hours flow are sufficiently large.

Dosing tanks are important adjuncts of intermittent sand filters, particularly in winter. The following comments are made on contact beds and sprinkling filters:

> Contact filters, of which we have two successful examples in Ohio, afford means of producing on a comparatively small area of land and with little fall, an effluent which is sometimes but not always non-putrescible. Such effluents are only fit to discharge into streams having considerable dry weather flow, from which no public water supply is drawn. Our studies would seem to indicate the fact that only the weaker sewages can be satisfactorily purified by this method alone. When followed by secondary treatment on filters of sand or other material, this method may be used to advantage with stronger sewage.
>
> The automatic controlling devices, usually employed with contact filters, have at the larger plants been generally satisfactory; but those at several of the smaller plants have proved to be absolute failures. These automatic controlling devices have at one place been omitted, and the flow of sewage is changed from filter to filter by the attendant with more or less regularity.
>
> Sprinkling filters, as shown by the results of experiments in Ohio, afford a means of producing a non-putrescible effluent upon an area considerably less than that required for contact filters, and at a correspondingly less cost. The head for operating sprinkling filters, on the other hand, is greater than that required for contact filters. The absence at the end of the investigation of any completed sprinkling filter plant in Ohio has prevented the securing at first hand of any data regarding this method.

The average cost of construction of ten representative sewage purification plants in Ohio is $4.17 per capita of tributary population. The annual per capita operating expenses of these plants range from 16 to 79 cts. and average 47 cts. These figures include interest charges, "which in several cases equal or exceed the amount expended for actual maintenance." The operating cost of institutional plants [appears] to be small because "there are no actual interest charges, and the plants can usually be operated by the inmates or by one of the employees of the institution, who may in addition have other duties."

Supplementary studies dealt with the disinfection of sewage effluents and have been reported at length in Bulletin No. 115, United States Department of Agriculture, Bureau of Plant Industry. (See also Eng. News, Nov. 21, 1907).

Mr. Pratt states that the plant for the disposal of acid iron pickling liquids from the works of the Shelby Steel Company, Shelby, Ohio, installed subsequent to an investigation by the State Board of Health in 1906, has proved satisfactory. (See Eng. News, Nov. 22, 1906.)

TABLE I.—WATER PURIFICATION PLANTS IN USE OR UNDER CONSTRUCTION IN OHIO IN DECEMBER, 1907.

Batavia,	Gallipolis,	Rocky River,
*Bellaire,	Geneva,	*Sandusky,
Bucyrus,	*Ironton,	Springfield,
*Camp Perry,	Linwood Park,	*Toledo,
Cincinnati,	Lorain,	Upper Sandusky,
*Columbus,	Marietta,	Vermilion,
Conneaut,	Newark,	Warren,
Dennison and Uhrichsville,	Oberlin,	Youngstown.
Elyria,	Pomeroy and Middleport,	
Fostoria,		

*Plants under construction.

TABLE II.—SEWAGE PURIFICATION PLANTS IN OPERATION OR UNDER CONSTRUCTION IN OHIO, IN DECEMBER, 1907.

Municipal Plants.

Alliance,	Geneva,	Oberlin,
Ashland,	Glenville,	Plain City,
Canton,	Kenton,	*Ravenna,
Clyde,	Lakewood,	*St. Marys,
*Columbus,	London,	Shelby,
Delaware,	Mansfield,	Westerville,
East Cleveland,	Marion,	Xenia.
Fostoria,	*Medina,	

Institutional Plants.

Alliance, Fairmount Children's Home.
*Bucyrus, Crawford County Infirmary.
*Camp Perry, Ottawa County.
Collinwood, L. S. & M. S. Railway.
Dayton, Montgomery County Infirmary.
*Delaware, Girls' Industrial Home.
Gallipolis, Gallia County Infirmary.
Gallipolis, State Hospital for Epileptics, Main Building
Gallipolis, State Hospital for Epileptics, Cottage I.
Granville, Shepardson College.
Kenton, Hardin County Infirmary.
Lancaster, Boys' Industrial School.
Mansfield, State Reformatory.
Marietta, Washington County Infirmary.
Massillon, State Hospital for Insane.
Morgans, State Institution for Feeble Minded Youth.
North Amherst, Ohio Quarries Company.
Sandusky, Soldiers' and Sailors' Home.
Shepards, St. Marys of the Springs.
Toledo, State Hospital for Insane.
Warren, Trumbull County Infirmary.
Warrensville, Cleveland Tuberculosis Farm Colony.
Wooster, Wayne County Infirmary.

*Plants under construction.

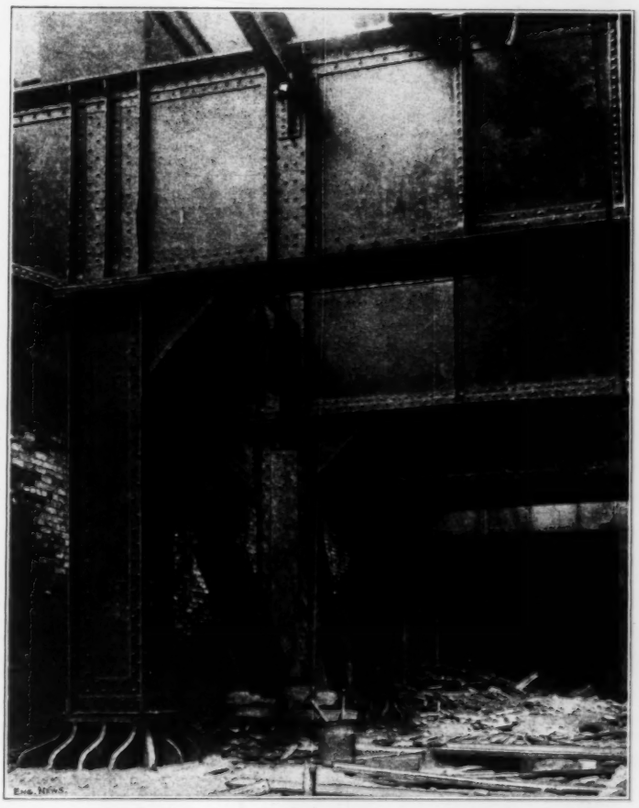


FIG. 7. HEAVY COLUMN AND GIRDER CONSTRUCTION SUPPORTING FIRST FLOOR AND COLUMNS OF PROSPECT AVE. SECTION, CLEVELAND HIPPODROME BUILDING.

TABLE III.—TABULAR STATEMENT OF THE METHODS EMPLOYED AT THE 46 SEWAGE PURIFICATION PLANTS IN USE OR UNDER CONSTRUCTION IN OHIO, DECEMBER, 1907.

No. of Plants.	Combined population tributary to plants.	Preliminary treatment (Preceded by Screening in all but three cases).	Final treatment.
5	4,300	None	Intermittent filtration or similar treatment.
2	3,000	Sedimentation with continuous flow to filters	Intermittent sand filtration or similar treatment.
11	10,400	Flush tanks or storage reservoir	Intermittent sand filtration or similar treatment.
3	350	Septic tank	None.
1	2,000	Septic tank without dosing tank	Intermittent sand filtration.
5	5,500	Septic tank with dosing tank	Intermittent sand filtration.
2	500	Septic tank	Intermittent filtration through coke.
7	28,800	Septic tank	Contact filters.
1	8,000	Septic tank	Contact filters followed by intermittent sand filtration.
3	175,000	Septic tank	Sprinkling filters.
1	500	Septic tank	Sprinkling filters, sand filtration and chemical disinfection.
1	7,000	Septic tank	Continuous filtration with forced aeration.
2	9,000	Chemical precipitation	None.
1	9,000	*Chemical precipitation	*Contact filter followed by intermittent sand filtration.
1	3,200	Chemical precipitation	Sewage discharged over land to water course.

*Original plan. Plan abandoned after ten year's operation, during which the final treatment was generally omitted.

Since this article was put in type we have received a copy of a new law, which gives the State Board of Health greatly increased supervisory powers over water and sewage purification plants. A report of the new law follows this article.

THE NEW OHIO WATER AND SEWAGE PURIFICATION AND STREAM POLLUTION LAW.

On March 26 the Ohio Legislature passed a bill which gives the State Board of Health power to require the construction of sewage and water purification plants, as well as a large measure of control of such plants after they have been put in operation. Orders of the board must be approved by the Governor and Attorney General. Appeals can be taken, but these are adjudged by engineers chosen in each case instead of by a court of law. Personal fines of $500 become automatically effective against municipal officials or other individuals for non-compliance with the law, and legal machinery for collecting these fines is provided by the statute.

The new law is in accordance with recommendations made in a special report of the Ohio State Board of Health, abstracted elsewhere in this issue.

As this bill is one of the most important sanitary enactments ever passed, and may well serve as a model for legislation by other States, we reprint it in full, as follows:

A BILL TO AUTHORIZE THE STATE BOARD OF HEALTH TO REQUIRE THE PURIFICATION OF SEWAGE AND PUBLIC WATER SUPPLIES AND TO PROTECT STREAMS AGAINST POLLUTION.

Be it enacted by the General Assembly of the State of Ohio:

Section 1. Whenever the council, or board of health of any city or village, or the commissioners of any county, or the trustees of any township make complaint in writing to the state board of health, setting forth that a city, or village or corporation or person is discharging or permitting to be discharged any sewage or other wastes into any stream, water course, lake or pond and is thereby creating a public nuisance detrimental to health or comfort, or is polluting the source of any public water supply, it shall be the duty of the state board of health to forthwith inquire into and investigate the conditions complained of; and whenever the state board of health finds after investigation that the source of public water supply of any city, village or community in this state is being subject to contamination or has been rendered impure by reason of the discharge of sewage or other wastes, or in any other manner by any city, village, corporation or person; or whenever said board finds that such sewage or other wastes have so corrupted any stream, water course, lake or pond as to give rise to foul and noxious odors, or to conditions detrimental to the health or comfort of those residing in the vicinity of such stream, water course, lake or pond, it shall notify such city, village, corporation or person causing the contamination or pollution of any such stream, water course, lake or pond of its findings and give them an opportunity to be heard, and after such hearing if the state board of health determines that improvements or changes are necessary and should be made, it shall report its finding to the governor and attorney general, and upon their approval said board shall notify such city, village, corporation or person to install such works or means satisfactory to said board, for purifying or otherwise disposing of its sewage or other wastes, or to change or enlarge existing works in a manner to be satisfactory to said board; such works or means must be completed and put into operation within a time to be fixed by said board, which time shall be subject to the approval of the governor and attorney general. Provided that no city or village that is now discharging sewage into any river which separates the state of Ohio from another state shall be required to install sewage purification works as long as the unpurified sewage of cities or villages in any other state is discharged into said river above said Ohio city or village.

Sec. 2. Whenever the board of health or health officer of any city or village, or 10% of the electors thereof file with the state board of health a complaint in writing, setting forth that it is believed that the public water supply of such city or village is impure and dangerous to health, it shall be the duty of the state board of health to forthwith inquire into and investigate the conditions complained of; and whenever the state board of health finds after investigation, that the public water supply of any city or village is impure and dangerous to health and that it is not practicable to sufficiently improve the character of such supply by removing the source or sources of pollution affecting it, or if said board finds that such water supply is being rendered impure by reason of improper construction or inadequate size of existing water purification works, it shall notify such city, village, corporation or person owning or operating such water supply of its findings and give them an opportunity to be heard, and after such hearing if the state board of health determines that improvements or changes are necessary and should be made, it shall report its findings to the governor and attorney general, and upon their approval said board shall notify such city, village, corporation or person owning or operating such water supply to change the source of supply or to install and place in operation water purification works or device satisfactory to said board, or to change or enlarge existing water purification works in a manner satisfactory to said board, within a time to be fixed by said board, which time shall be subject to the approval of the governor and attorney general.

Sec. 3. Whenever the state board of health finds, upon investigation, that any water or sewage purification works, on account of incompetent supervision or inefficient operation, is not producing an effluent as pure as might reasonably be obtained from such plant, and by reason of which any public water supply has become dangerous to health, or any stream or body of water has become offensively polluted, or has become a public nuisance, said board shall issue an order to the officer, board or department of any city or village, or the corporation or person having charge of or owning such plant, to secure an effluent as pure as might be reasonably expected from such plant and satisfactory to said board; and if such officer, board or department of any city or village, or such corporation or person fails, for a period of five days after receiving such order, to secure such an effluent, the state board of health shall report the fact to the governor and attorney general and upon their approval may order such officer, board or department, or owner of such plant, to appoint within ten days, and pay the salary of, a competent person to be approved by said state board of health to take charge of and operate such works so as to secure the results demanded by the state board of health.

Sec. 4. If in any case any order of the state board of health, when approved by the governor and attorney general, and made in pursuance to the provisions of this act, is not acceptable to any city, village, corporation or owner affected thereby, such city, village, corporation or owner shall have the right of appeal as follows, to-wit: The necessity for and reasonableness of such order may be submitted to two reputable and experienced sanitary engineers, one to be chosen by the city, village, corporation or owner to which such order of the state board of health applies and the other chosen by the state board of health, who shall not be regularly employed by said board and who shall act as referee engineers. If the engineers so chosen are unable to agree then they shall choose a third engineer of like standing, and the vote of the majority shall be final and binding. The referee engineers, herein provided for, shall have power to affirm, modify, or reject, the order of the state board of health submitted to them, and their decision, as reported in writing to the governor and attorney general, which shall be rendered within a reasonable time, shall be accepted by the state board of health, and shall be enforced by said board in the manner provided for in this act. The fees and expenses of said referee engineers shall be equally divided between the city, village, corporation or owner requesting such reference and the state board of health.

Sec. 5. It shall be the duty of every such municipal council, department or officer having jurisdiction to provide for the raising of revenues by tax levies, sale of bonds, or otherwise to take all steps necessary to secure the funds for any such purpose or purposes; and when so secured, or the bonds thereof have been authorized by the proper municipal authority, the same shall be considered as in the treasury and appropriated for such particular purpose or purposes, and cannot be used for any other purpose; provided, that the bonds herein authorized to be issued for the purposes enumerated in this act shall not exceed 5% of the total value of all property in any city or village, as listed and assessed for taxation, which may be in addition to the total bonded indebtedness allowable under the provisions of Sec. 2835 of the Revised Statutes, but the question of the issuance of such bonds shall not be required to be submitted to a vote.

Sec. 6. If any council, department or officer of any municipality, or person or private corporation, shall fail or refuse for a period of 30 days after notice given him or them by the state board of health of its findings and the approval thereof by the governor and attorney general of the state of Ohio, to do and perform any act or acts required of him or them to be done and performed by this act, such members of council or department, and such officer or officers, or person or private corporation shall be and become personally liable for such default, and upon conviction thereof shall forfeit and pay to the state board of health $500 * * * to be deposited with the state treasurer to the credit of said board; provided, however, that the governor and attorney general, upon good cause shown, may, in their discretion, remit said penalty, or any part thereof.

Sec. 7. An action may be begun for the recovery of any such penalty by the prosecuting attorney of any county in the name of the state of Ohio in the court of common pleas of such county having jurisdiction of any such party or parties; or it may be begun by the attorney general in any such county or in the county of Franklin, as provided for by Secs. 210 and 211 of the Revised Statutes of Ohio.

A GRAPHICAL COMPARISON OF VARIOUS LOG RULES.

By ARTHUR H. MORSE.*

According to a handbook published a few years ago by the Bureau of Forestry,† more than thirty different "log rules" are in use in the United States. All these rules profess to accomplish the same thing, viz., to provide means for ascertaining the number of board feet of 1-in. lumber which can be sawn from a log of given diameter and length; in other words, to give the "scale" of a log in board feet. It is the purpose of the present article to compare the principal log rules.

Some of the log rules are of obscure origin. Some are known to have been computed from diagrams, a diagram being made for each diameter to show how the circular cross-section of the log will divide into inch boards with suitable allowance for saw-kerf. Other rules were compiled from records kept at the saw mill of the quantities of boards actually obtained from logs of various sizes. Still others were computed by rule-of-thumb, assuming either a fixed or a variable proportionality between the cubical contents of a log and its scale in board feet.

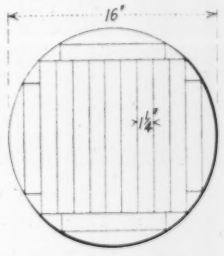


Fig. 1. Diagram of 16-in. Log, Divided into 1¼ in. Boards; Maine Rule.

The Holland or Maine Rule was computed from diagrams similar to the one shown by Fig. 1, which is the diagram for a 16-in. log. The 16-in. circle represents the small end of the log inside the bark. The log is first "squared," and the inscribed square is divided into strips 1¼ ins. wide, thus allowing ¼ in. for saw-kerf. If the slabs are large enough to produce a board 6 ins. wide or more, such boards are included in the scale of the log.

The accompanying chart, Fig. 2, is the result of an attempt to express the Maine Rule as a simple formula which would enable anyone to compute the scale of a log without referring to a table or using a scaler's stick. In making this chart, the values given by the Maine Rule for logs 10 ft. long were plotted as ordinates on the squares of the diameters as abscissas. If the scale of the log is proportional to its cubical contents (that is, to the square of the diameter, length being constant), the rule will be represented on this chart by a straight line passing through the origin. The corresponding formula is:

$$B = KD^2L$$

in which

B = scale of log, in board feet.

D = diameter of log, in inches, measured inside of bark at small end.

L = length of log, in feet.

K = an arbitrary constant.

It will be seen from the chart that this formula can be made to express the Maine Rule almost exactly, but three different values of K are required, as follows:

When D is 18 ins. or less, $K = .044$.
When D lies between 18 ins. and 28 ins., $K = .047$.
When D is 28 ins. or more, $K = .049$.

It is reasonable to suppose that the proportion of material wasted in the slabs is less in large logs than in small ones. This would explain the peculiarity of the Maine Rule just noted. The same fact is also taken into account by two other rules which are widely used, viz., the Doyle Rule and the Forty-five Rule.

The formula for the Doyle Rule, using the symbols already defined, is

*Care The Portland Co., Portland, Me.

†The Woodsman's Handbook, by Prof. H. S. Graves, published as Bulletin 36 of the Bureau of Forestry, U. S. Department of Agriculture, Washington, D. C.

$$B = \left(\frac{D-4}{4}\right)^2 L$$

Plotted on the chart it is a curve concave on the upper side as shown.

The Forty five Rule* may be expressed in the form $B = K D^2 L$, but in this case K has a value which increases as D increases, such that

$$K = \frac{33 + \frac{D}{2}}{1{,}000}$$

value of .033 to the values .038 for a 10-in. log, .043 for a 20-in. log, and .048 for a 30-in. log, approaching coincidence with the Maine and Doyle rules for the larger diameters.

The Old Scribner rule is said to have been derived from diagrams. On the chart it appears as a very irregular line, and no attempt was made to express it by a formula.

The result given by each of the other rules plotted in Fig. 2 was arrived at by a mathematical process which was in every case reducible to the form $B = K D^2 L$, a separate value of K being found for each rule. The statements of many of the rules were ingeniously complicated, notably that of the "Forty-five" rule cited.

The chart presents striking discrepancies in scales given by different rules for the same log, discrepancies amounting in some cases to more than 30% of the larger value. In these days of widespread standardization in almost all departments of industry it seems remarkable that our "standards" for the measurement of lumber should still show such lack of uniformity. Is not the time ripe for some one with influence to take the initiative and institute a reform?

The values given for the Maine rule were taken from a scaler's stick in the writer's possession. Particulars in regard to the other rules were obtained chiefly from the Bureau of Forestry bulletin referred to at the beginning of this article.

HOW TO TRAP RATS.

In fighting the plague which has prevailed to some extent in San Francisco and other Pacific Coast cities of late, a large amount of rat catching has been done. Inasmuch as rats sometimes have to be combatted by engineers and contractors in order to put them down as a mere nuisance, we reprint herewith an article on the subject by Passed Assistant Surgeon W. C. Rucker, of San Francisco, which appeared in "Public Health Reports" of the U. S. Public Health and Marine-Hospital Service for Feb. 28, 1908.

The following is a summary of a collection of articles written by the employees of the U. S. Public Health and Marine-Hospital Service engaged in rat catching at San Francisco, Cal. These men have demonstrated their knowledge of the subject by continuous large catches and what is detailed here is the result of actual experience:

Rats are to be found where there is an abundant food supply for them. Therefore, the best places to trap rats are slaughter-houses, meat markets, chicken houses, in and around garbage cans, and places where garbage is usually placed. If a rat is deprived of this food supply it will be attracted by the bait in the trap and thus enter the trap.

The large 19-in. French wire cage trap has given very good results where rats are plentiful. It should be made of stiff heavy wire and well reinforced, as a large, strong rat will force his head between the wires of a weak trap and thus escape. Before setting, the lever on the trap should be tested to see that it works properly. The trap should be placed on a hard surface with the rear end a little higher than the entrance, so that the trap will close promptly. When setting the trap in an open place it should be fastened to a board on which about an inch of soft dirt has been spread. Place the trap where rats usually go for food, or in a runway, and disturb the surroundings as little as possible. It is sometimes well to place the trap near dripping water, as the rats may go there to drink. If the trap is set in hay, straw, or wood, it should be covered (with the exception of the entrance) with the same material. When this is not possible, it should be covered with a piece of sacking, or placed in a dark corner, or beneath the floors. When setting the traps in the sewer, a dry place should be chosen.

FIG. 2. GRAPHICAL COMPARISON OF SOME LEADING LOG RULES.
(Ordinates Give Board Feet in Log 10 ft. Long.)

Rules represented on this chart by a straight line have the formula
$B = K D^2 L$,
where B = "Scale" of log in board feet.
D = Diameter of log, in inches, measured inside of bark at small end.

The value of K for the different rules is given below (except for the Doyle and equivalent rules). Where K varies with D, the rule is represented by a curved line. The "Old Scribner" rule is irregular, as shown by the plotted line, and is not represented by a formula.

Doyle or Scribner Rule, Connecticut River Rule, St. Croix Rule, Thurber Rule, Moore & Beeman Rule: $B = \left(\frac{D-4}{4}\right)^2 L$.

Maine, Holland or Fabian's Rule (slightly modified to fit formula): $K =$ {0.044 for D up to 18 ins.; 0.047 for D from 18 to 28 ins.; 0.049 for D over 28 ins.}

Forty-five Rule (not plotted): $K = \frac{33 + \frac{1}{2} D}{1{,}000} =$ {0.038 for $D = 10$ ins.; 0.042 for $D = 20$ ins.; 0.048 for $D = 30$ ins.}

Square of Three-Fourths Rule, Crooked River Rule, Noble & Cooley Rule, Cooke Rule, Portland Scale, Lumberman's Scale: $K = \frac{3}{64} = .0468$.

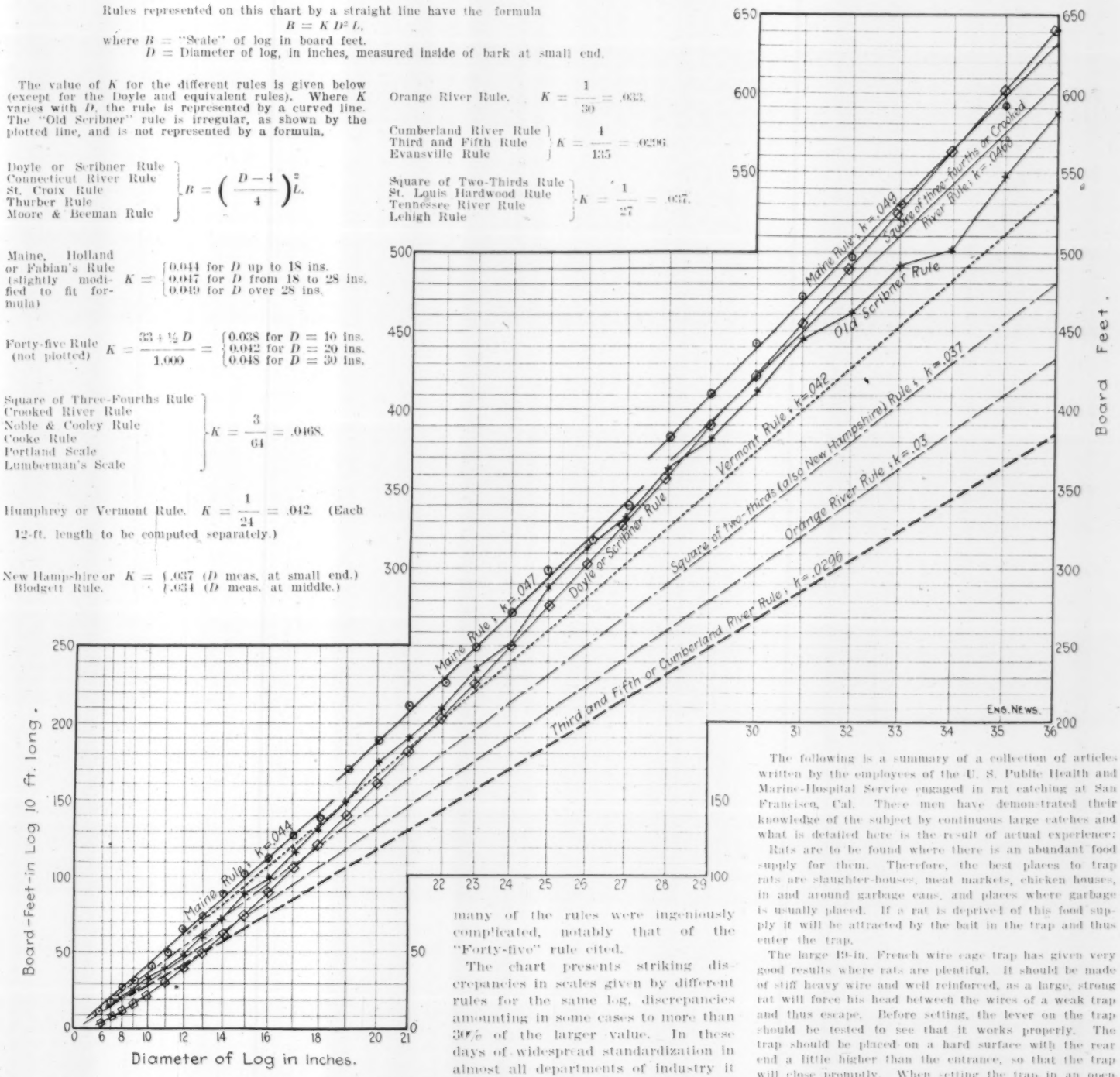
Humphrey or Vermont Rule. $K = \frac{1}{24} = .042$. (Each 12-ft. length to be computed separately.)

New Hampshire or Blodgett Rule. $K =$ {.037 (D meas. at small end.) .034 (D meas. at middle.)

Orange River Rule. $K = \frac{1}{30} = .033$.

Cumberland River Rule, Third and Fifth Rule, Evansville Rule: $K = \frac{4}{135} = .0296$.

Square of Two-Thirds Rule, St. Louis Hardwood Rule, Tennessee River Rule, Lehigh Rule: $K = \frac{1}{27} = .037$.


Board-Feet-in Log 10 ft. long.
Diameter of Log in Inches.
Board Feet.
Maine Rule; K=.044
Maine Rule; K=.047
Maine Rule; K=.049
Doyle or Scribner Rule
Old Scribner Rule
Vermont Rule; K=.042
Square of two-thirds (also New Hampshire) Rule; K=.037
Square of three-fourths or Crooked River Rule; K=.0468
Orange River Rule; K=.03
Third and Fifth or Cumberland River Rule; K=.0296
ENG. NEWS.

This rule has not been plotted, but it may be compared with the others by noting the successive values of K, which vary from a minimum

*So called from an arbitrary constant used in the rule as originally stated, as follows: "For a 24-in. log multiply the square of the diameter, that is, 24, by the length of the log and the result by 45, then point off three places. The figures at the left of the decimal point will represent contents in board feet. For every variation of 2 ins. in the diameter from the standard 24-in. log add or subtract 1 from the number 45 in the formula, according as the diameter is larger or smaller than 24 ins."

The rat is more or less of an epicure, therefore the bait should be changed at frequent intervals. For bait the rat should be given food which it is not usual for him to obtain. In a meat market, for example, vegetables are the best bait, while in a location where vegetables are plentiful, fresh liver and fish heads or a little grain are best. The following may be suggested as good bait to be used: Fish, fish heads, raw meat, cheese, smoked fish, fresh liver, cooked corned beef, fried bacon, pine nuts, apples, carrots, and corn. When trapping in chicken yards a small chick or duckling is a remarkably good bait. When a large number of rats are caught in one trap, search for the female rat and leave her alive in the trap, as she may call in the young or the males. The bait should be fastened to the inner side of the top of the trap with a piece of fine wire, so that the first rat that goes in can not force the bait underneath the pan and thus prevent the entrance of other rats. A few grains of barley should be scattered near the entrance of the trap and a small piece of cheese or meat fastened to the pan with a bit of wire. It is often well to touch the pan with a feather which has been dipped in oil of anise or oil of rhodium. The trap should be smoked with a piece of burning newspaper to take away the smell of the human hands, or of rats which

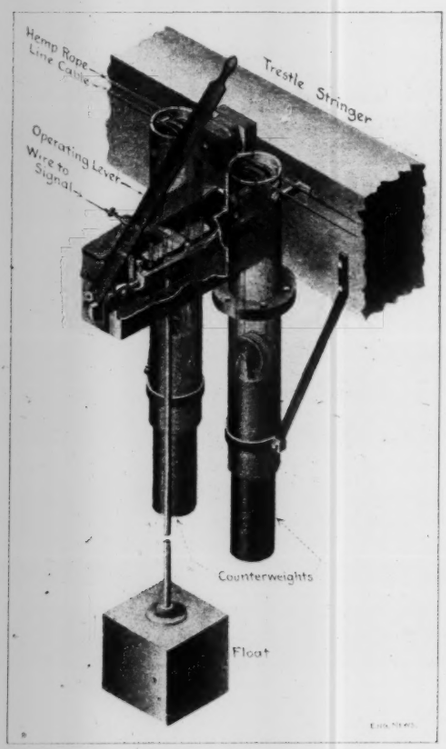


Fig. 1. Operating Device of the Garrett Signal for Railway Trestles.
Railroad Supply Co., Chicago, Makers.

have been caught in the trap. Do not handle the trap after burning it out. When trapping in a neighborhood where rats are known to exist, the traps should not be moved for three or four days unless they have rats in them, as it is well for the rats to become accustomed to seeing the traps and thus careless about entering them. It is not wise to kill rats where they are caught, as the squealing may frighten away the other rats.

Snap or spring traps are best for use in houses and stores, with the exception of fish and meat markets. Snap traps are best for use in runways and on beams and shelves. It is sometimes well to disguise the trap by covering its floor with a little sawdust or dirt. The traps should first be tested to see that they work properly and that the staples are secure. New traps should be smoked or stained to render them of an inconspicuous color.

The bait should consist of some firm material, such as fried bacon or tough meat, and should be tied on so that the rat will be obliged to pull on it and thus spring the trap. The trap should be placed in a corner or close to the wall on a flat, hard surface in order that the rat cannot spring it with his tail or by walking on it.

In warehouses and granaries large numbers of rats may frequently be trapped by using a barrel or garbage can having a metal top which is carefully balanced. A large piece of strong cheese is placed in the middle of the cover and a plank laid from the floor to the edge of the barrel. The rat runs up the plank and on the smooth lid, which tips, precipitating the rat into the barrel.

A SPECIAL SIGNAL TO INDICATE FIRES OR WASHOUTS AT RAILWAY TRESTLES.

With the large number of timber trestles on American railways, train accidents due to the injury or destruction of trestles by fires and floods are not uncommon. Many more accidents of this sort are averted by the watchfulness of section men and track walkers. A special device has been recently invented to give automatic warning to trains of damage to structures of this class.

A tarred hemp rope is led around the structure, being carried by pulleys on the stringers. At each end of the trestle the rope is attached to a wire cable which runs to the signal operating device shown in Fig. 1, this being placed near one end of the trestle. Each wire cable passes over blocks on a counterweight sliding in a cylindrical guide, the counterweights keeping the rope tightly stretched. Between the guide cylinders is a case containing the signal releasing mechanism, which is operated by a weight normally held up by the rope. The operating lever of the device is held by a trip, and is connected by a wire to a counterweighted lever on the signal post. Should the hemp rope be burned, or be pulled apart by the destruction of part of the trestle, the weight falls, and releases the trip so that the operating lever is free to move. This allows the counterweight on the signal post to fall, setting the signal at the danger position. A lever at the operating device allows of the signal being thrown by hand, in order to see if it is in proper operating condition.

A float suspended from the operating device at the level of the danger line of floods will be raised when the water reaches this level and trip the operating lever, so that the signal will also indicate dangerous flood conditions. Where the structure is short one signal will suffice; but if necessary a signal may be placed near each end, at the proper distance to enable trains to stop before reaching the trestle.

This signal device is in experimental use at a trestle on the Chicago, Burlington & Quincy Ry., where several fires and washouts have occurred. This installation, shown in Fig. 2, has a two-arm semaphore signal at one end of the structure, there being a clear view from either direction. The device is the invention of Mr. J. O. Garrett, and is being introduced by the Railroad Supply Co., of Chicago.

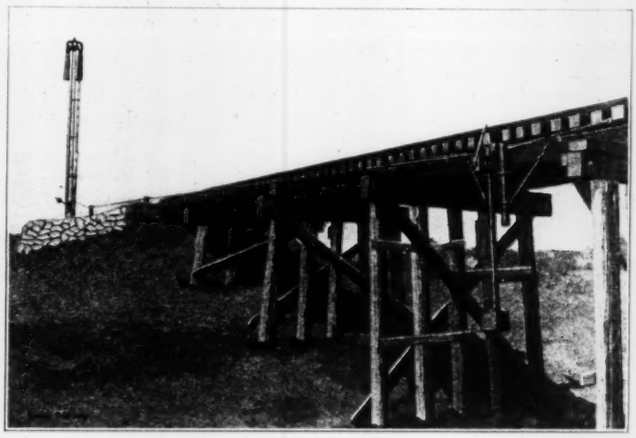


FIG. 2. THE GARRETT SIGNAL DEVICE ON A TRESTLE OF THE CHICAGO, BURLINGTON & QUINCY RY.

It will be apparent, of course, that damage may be done to a trestle which this device may not record. Fire may possibly injure a structure and yet not advance far enough to burn off the tarred rope before a train comes along. Signals require a certain amount of care and attention to keep them in operative condition; particularly signals which, like this, are never operated except in cases of an emergency which may not occur in many years. Many trestles are located on parts of the road remote from the stations, and such signals might be neglected by the track forces. It is fair to point out, however, that two of the most terrible railway disasters on record—that at Chatsworth, Ill., in August, 1887, where 73 persons were killed and 374 injured, and that at Pueblo, Colo., in August, 1904, where 96 persons lost their lives—would apparently have been prevented by a simple apparatus of this kind.

A THIRTY-SIX-STORY BUILDING is to be built in New York City, on West St., near the Battery. The main building consists of two wings, 16 and 31 stories high each, with an intermediate 36-story tower, the irregular height making the building harmonize with the adjoining Whitehall Building.

THE WORK OF THE SANITARY AND DRAINAGE COMMISSION OF CHARLESTON COUNTY, S. C.

A unique example of drainage work which might be followed with advantage in many other sections is being carried out in the vicinity of Charleston, S. C., by the Sanitary and Drainage Commission of Charleston County. In addition to drainage, a considerable amount of road improvement work is being done. Both kinds of work are being executed by means of convict labor drawn from the county jails. The work has been in progress for a number of years past, and is described from year to year in annual reports issued by the Commission. Mr. S. Lewis Simons is Engineer to the Commission, and Mr. James Cosgrove is Secretary.

In the report of the Commission for the year 1906, there is a statement by Mr. Cosgrove as to how the work came to be started. Mr. Cosgrove says that some years ago he was surprised to find that the entire white population of Charleston County, outside of the city of Charleston, did not exceed 2,500, and that of 400,000 acres "of the most fertile lands in the world," only some 40,000 were under cultivation. The reason for this was that no white man dared to live in that section during the summer, for fear of "country fever"—really malaria.

Legislation was secured authorizing the formation of drainage commissions, and in accordance therewith a Commission was organized for Charleston County. After a four-years' fight an appropriation was secured making it possible to begin work, and on April 2, 1902, work was started with 17 convicts. In 1906, 87 convicts were at work, divided into two camps in charge of a superintendent, a foreman and six guardsmen. The cost of the convict labor to the Commission is 50 cts. per man per day. This includes feeding, clothing, guarding and medical attendance, together with all tools and materials used in the work. The task of each convict was about 7 cu. yds. of excavation per day in 1906.

As the result of the first four years' operations, about 85 miles of canals and ditches were dug and some 15,000 acres of land reclaimed. This reclamation was followed by the building of a considerable number of houses.

The health of the convicts has been good. The stockades in which the convicts sleep are carefully screened against mosquitos. All drinking water used is boiled as a protection against the possible outbreak of typhoid fever.

During the year 1907, about 13 miles of ditches and canals were built. The total expenditures of the Commission in 1907, including considerable items of capital outlay, were $24,301.

The Commission is empowered to require persons to connect any private ditches with the ditches of the Commission when the latter are accessible. The Commission is also empowered to condemn lands necessary for drainage purposes, and to assess benefits upon land drained.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
ATLANTA: Candler Building
RUDOLPH MOSSE, BERLIN AND HAMBURG, GERMANY
Z. P. MARUYA & CO., Ltd., TOKYO, JAPAN

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United States and Possessions, Mexico and Cuba, One Year, $5.00.
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Foreign Countries, Regular (Thick Paper) Edition, One Year $9.00. (£1-18-0.), 45 Francs or 37 Marks.
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Entered at the New York Post-Office as Second-Class Matter

In view of the extent to which the attention of the engineering profession is now concentrated on the conservation of natural resources, we give large space this week to a summary of recent work toward that end, carried on by the United States Geological Survey.

As we have before pointed out in these columns, the engineering profession has a clearer realization than any other body of men of the results which are certain to follow the reckless waste of nature's gifts.

The engineer alone of all men has a practical appreciation of the scientific fact that it is impossible to create something out of nothing. We may, indeed, learn how to substitute one product for another, but such substitutions are usually accompanied by economic loss.

Upon the engineering profession, therefore, a large responsibility rests. The engineer is like a man, resident in a community protected by dikes from the floods of river or ocean, who should see people excavating material from the dikes and carrying it away, in ignorance of the danger and destruction which they were inviting. The man who should witness such action and realize its consequences could not fail to sound public warning and exert every possible influence to make good the damage and avert the danger. So with the engineering profession and the waste of nature's gifts. There is laid upon the profession at the present time a great responsibility and an unusual opportunity for leadership in a movement promising vast public benefits.

Our prediction a month ago that the Collinwood holocaust would lead to a radical overhauling of school buildings throughout the United States has been remarkably fulfilled. From every part of the country reports come to us of action by public bodies for the safeguarding of dangerous buildings and providing that only fireproof structures shall be erected in the future. It is not unreasonable to expect that at least a hundred million dollars will be expended in fireproof school buildings in the United States during the next five years, traceable to the influence of the Collinwood disaster.

By a sort of reflex influence, the reform appears likely to be extended to other public buildings as well. The public is being educated by this agitation to the dangers of inward opening doors, turns in stairways, loose seats in audience rooms, defective heating and ventilating apparatus, and fire spreading materials in finish. It will be easier henceforth for the progressive elements in a community to carry the day when the safeguarding of any proposed public building against dangers of fire or panic becomes a matter of controversy.

The February statistics of internal commerce in the United States, issued by the Bureau of Commerce and Labor, shed an interesting light on the industrial situation. It is clear from the figures that the falling off in railway business, of which so much has been heard, is due chiefly to slackening in the iron and steel and building industries. Traffic in food products is as brisk as in 1906 or 1907, as the following little table indicates:

For the month of February:	1908.	1907.	1906.
Receipts of live stock at 7 primary markets (1=1,000).....	3,680	3,312	3,313
Packing house products shipped from Chicago (1=1,000 lbs.)..	221,832	208,604	214,274
Grain and flour receipts at 4 Atlantic coast cities (1=1,000 bu.)	18,384	18,602	23,022

In the coal and coke traffic, figures for seven leading trunk line railways show a falling off of 20% over corresponding figures for 1907. Connelsville coke production is 57% below that of a year ago, but is increased over the figures for January. The value of building permits granted in 50 leading cities during February was $25,118,508. While this is 33% below that reported for February, 1907, it is a notable increase over the records of the three preceding months, and the improvement is said to be especially marked in the cities of the Central West.

The American Railway Association's Committee on Car Efficiency reported on April 1 that the surpluses of freight cars on March 18 had been reduced to 297,042, which compares with a surplus of 341,763 on Jan. 8. On March 4 the surplus cars numbered 314,992. The decrease during the following fortnight is thought to be partially due to the activity of railways and coal users in stocking up with coal in anticipation of the shutting down of the coal mines on April 1 because of the deadlock between the coal miners and the mine operators.

It is noteworthy that Mr. Franklin K. Lane, of the Interstate Commerce Commission is publicly quoted as predicting that by the crop moving season next fall the railways will again be short of cars to meet shippers' demands.

This is a country of free speech and a free press. If anybody believes a certain government policy is to the public advantage, or even to his own personal advantage, he may speak and write in advocacy to his heart's content, or he may hire others to speak and write.

The opponents of municipal ownership, for example, whether they are opponents from pure patriotism, or because of personal interest, have a right to conduct a publicity campaign against municipal ownership and to bear any expenses in connection therewith.

It is further to be noted that in conducting publicity campaigns of this sort, it is not necessary to stick to the truth. If misstatements about a person are published, the law of libel is available to punish the offender; but a governmental policy is not protected by any libel law.

We could cite a score of matters of public interest and importance in which organized publicity campaigns have been and are being conducted. The press far and wide is deluged with copy prepared to advocate the views of certain private interests. Recent disclosures in the insurance and street railway investigations in New York City have revealed the methods by which some of these publicity campaigns are conducted and financed.

It is apparent, of course, that no intelligent man, and certainly no member of the engineering profession, would be willing to form opinions on the basis of statements originating from such sources; yet we find many engineers quite uninformed of the extent to which this sort of work is going on, and unaware of the extent to which they should be on their guard in accepting statements made in newspapers, magazines and other publications.

In view of these facts, it has seemed to us that the circular letter printed below was worth the wider publicity which we now give it.

GREENWOOD WATER AND ELECTRIC LIGHT PLANT
(Municipal.)
Established 1898.
J. T. Simmons, A. F. McKissick, Dr. J. B. Hughey, Commissioners.
A. J. Sproles, Supt.
Artesian Water, 500,000 Gallon Cemented Reservoir, 250,000 Gallon Stand-Pipe, 2—8 × 14 Compound Duplex Fire Pumps, 58 Fire Hydrants, Domestic Pressure 50 lbs., Fire Pressure 125 lbs., 15 Miles Sewer.
Alternating Current, 2,300-110 Volts, 60 Cycle, 3 Phase, Steam and Hydro-Electric Power, 6,000 16 C. P. Incandescent Lamps, 75 A. B. Series Alternating Current Arc Lamps, 6—6 Amp. 250 KW. National Generator, Day Current.

Dear Sir: I have before me a booklet entitled "Defunct Municipal Lighting Plants," compiled by Mr. Arthur Hastings Grant, and published by the M. O. Publishing Bureau, New York, in which this plant—and may be yours—is set down as one of the number, and "Might as well be written off the books."

Of course we do not care—nor does any other of the slandered plants, which is every one he cites, if there is no more truth in what he says of them than of us—as our people are satisfied with municipal ownership and are not concerned about those of other municipalities.

I am of the opinion that their pamphlet is a fabrication—a tissue of falsehoods—from beginning to end. The gist of which is disclosed by a personal letter to me, in response to my order for a copy, from the publishers. Although the price is 40 cts. per copy, they state:

On your order, we will send complimentary copies to editors, mayors, councilmen, physicians, dentists, barbers, and libraries, because we believe such a distribution, at this time, will give facts on our side, and will have a profound influence in checking the municipal ownership movement. Even if there is no present agitation in your city, the placing of these in the hands of a number of your influential citizens will tend to prejudice them against municipal ownership, and make it difficult for a movement to get under way.

The interest all hirelings of trusts and corporations manifest in the welfare of the "dear people" is amazing.

A. J. Sproles, Supt.

Greenwood, S. C., March 29, 1908.

People of a misanthropic turn have often asserted that the world is hollow, just as victims of ennui and over-indulgence have long declared that the world is flat. Some of our readers may recall that a dozen years ago a curious little religious (or irreligious) sect, originating in Chicago, set out to run a line of levels on the Florida coast to make physical demonstration of the flatness of the earth. Now comes forward a similar supporter for the misanthropic pessimists, one Wm. Reed, declaring that the earth is a hollow sphere with holes about a thousand miles wide where the poles ought to be. He has organized "The Reed Hollow Earth Exploring Club (Inc.)," which held a public meeting in New York City on March 30 and announced plans to send an expedition to the North Hole, with instructions to crawl over the edge and explore the inside. Mr. Reed said "he had not the slightest hesitation in stating it as his belief that the inside is better than the out." We trust he will proceed with his propaganda and convert to his way of thinking a great many people who "never would be missed." If Mr. Reed will only take along the high financiers, the multi-married millionaires, the bomb-throwing anarchists, and various other trouble makers, to a residence on the interior, the rest of us will soon forget that this bright world ever seemed hollow.

ADVANCES IN STATE SANITATION IN OHIO.

Ohio has put itself in the forefront of State sanitation by the intelligent and progressive manner in which it has been dealing with stream pollution and water and sewage purification problems during the last dozen years. The advances made in Ohio, which have hardly been equalled by the work accomplished in any other State of the Union during the same period, have been due to the State Board of Health, but the Board could have done nothing had it not been empowered to act by the State Legislature and had not the Legislature had behind it an increasingly intelligent and appreciative public.

The first notable sanitary advance made by Ohio was to require municipalities to submit plans for new public water supplies and sewerage systems, including of course both water and sewage purification, to the State Board of Health for approval. Ohio did not lead the other States in this respect, although but few were in advance of it, for similar approval of such plans was already required in Massachusetts and of sewage disposal plans, only, in New York.

Soon after receiving the necessary authority to control the character of new water and sewage purification works, the Ohio State Board of Health began a systematic sanitary inspection of the streams and lakes of the State. Such work had already been carried on extensively in Massachusetts, but very little of the sort had been done elsewhere at that time.

Quite recently another great advance was made in Ohio. This was the authorization by the Legislature of a systematic study of the existing water and sewage purification plants in the State. An appropriation of $15,000 was made for this purpose and with it, aided by special engineers as assistants to the chief engineer of the Board and by additional laboratory assistants, there has been carried out during the past two years a unique investigation of all the water and sewage purification plants in operation in Ohio. An abstract of the preliminary portion of the very interesting report on these investigations is published elsewhere in this issue.

It must have occurred to a large number of the readers of Engineering News who have followed the supervisory work of State boards of health in the matter of water supplies and sewage disposal, that their best endeavors in these lines were largely negatived by the fact that almost if not quite without exception hitherto these boards have had no authority to enforce the carrying out of the plans as stipulated in their approval—if indeed the plans were ever carried out at all. In New York State, in particular, there must be stored away somewhere an immense number of plans for sewage purification plants more or less laboriously and skilfully drawn, properly signed and sealed as authorized by the old State Department of Health, but never executed in the smallest portion. It has been urged often enough, in one State and another, that the control of water and sewage purification plants entrusted to State boards of health ought really to extend beyond the plan-stage through construction; and the boldest and most progressive critics have even ventured to assert, though infrequently, that such plants as are built should be subject to supervision of the State board of health in order to make sure that they are properly operated.

The other States of the Union have left to Ohio the honor of providing ways and means for seeing that plants in operation are properly operated under the direction of sufficiently skilled men. The law entrusting this matter to the Ohio State Board of Health, which at the same time clothes it with authority to require either water or sewage purification plants to be built where necessary, is reprinted elsewhere in this issue. No one who reads this law, and we are sure a large number of our readers will give it careful examination, will deny that in passing it the Ohio Legislature took a great stride in advance and one for which it deserves the most hearty commendation of not its citizens alone, but those of the whole United States. With this law and the machinery provided for enforcing it, which machinery is one of the strong points of the law, it will be possible for the Ohio State Board of Health to do more than can be done in any other State in the Union towards protecting its streams and lakes from pollution and its citizens from the resulting offense to sight and smell and, of transcendent importance, from the dangers of typhoid and other intestinal infection.

It would be unfair to a number of other States of the Union if we did not refer to what some of them are doing to ensure a safe water supply and the proper disposal of sewage. The Massachusetts work has been mentioned, and, mentioned or not, is well known. The recently reorganized State health departments of New York and Pennsylvania make provisions for the approval of plans for water and sewage purification plants and for the compulsory establishment of such plants in certain cases, which until very recent times would have been considered decidedly radical. The State of Kansas has recently joined the ranks of American commonwealths that propose hereafter to safeguard their public waters. Presumably the recently reorganized State Board of Health of Virginia will be able to do much in the same line. New Jersey has had a State Sewerage Commission for some years, which has control over new sewage disposal schemes. Doubtless other States which we do not now bring to mind have power over plans for water and sewage purification.

It is a notable fact, and one which will deeply interest our readers, that those States which have made most advance in the sanitary work carried on by their boards of health have been provided sooner or later with engineers, or have at least had engineer members. The latter alone, helpful as they have frequently been, have rarely been sufficient. Just how many State boards of health now have chief engineers we cannot say, but we know that such officials exist and are doing a valuable work in Massachusetts, New York, Pennsylvania, Ohio, Indiana, Illinois (we think), Michigan, Minnesota, Kansas and Washington. In the first four of the States named the chief engineers have a number of assistants. This is certainly encouraging. In addition, of course many if not all these States have chemical and bacterial laboratories, and such laboratories are also provided in a number of the States still without the latter.

Finally, it is to be noted as a further matter for congratulation that the new Ohio law provides for appeal, in matters of dispute between the State board of health and local authorities or corporations, to engineer-arbitrators instead of to the courts. The significance of this will be seen and appreciated by all who have watched the floundering of law courts over engineering questions. We are sure that this is but the beginning of the increased recognition which is to be given to engineers in connection with the work of State and local boards of health and also, sooner or later, by whatever department of the Government finally is entrusted with the enlarged national health-protective work which is so urgently needed.

LETTERS TO THE EDITOR.

Credit for Design of Sluice Gates for Laguna Dam.

SIR: I wish to correct a statement in my article on "Electrically Operated Sluice Gates and Drop-Timber Regulator Gates for the Laguna Dam," appearing in Engineering News of Feb. 27, crediting the design of the gates to Mr. F. Teichman. The design was due to Mr. Richard G. Doerfling and he is so credited on the contract drawings of the Reclamation Service. Of this fact the writer was well aware and very much regrets that the erroneous credit was overlooked.

Very respectfully,

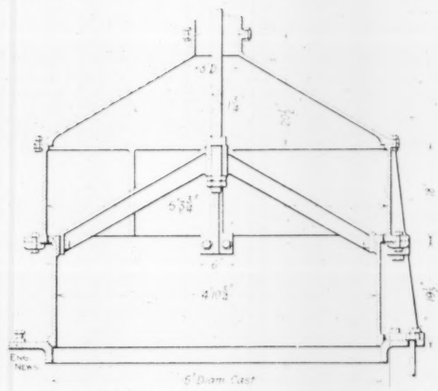
F. W. Hanna,

Engineer, U. S. Reclamation Service.

Washington, D. C., March 18, 1908.

Balanced Gate Valve Used on the Locks in the Muskingum River, Twenty Years Ago.

SIR: In your issues of Oct. 4 and 17, and Nov. 14, 1907, you illustrated some so-called balanced gate valves, one designed and patented within the last few years by Mr. John Peterson and the other designed about 1886 by the late Mr. Reuben Shirreffs, with some discussion as to the priority of the design. I enclose you herewith a tracing showing a quite similar valve installed by the late Col. Wm. E. Merrill, Corps of Engineers, U. S. Army, on the locks in the Muskingum River, O., nearly twenty years ago. It appears to be a somewhat better valve than either of the others, because the method of seating



Balanced Gate Valve Used on Locks in the Muskingum River, Twenty Years Ago.

is better. To attempt to make close joints at the upper and the lower seats is mechanically very difficult. In the Merrill valve only the lower seat is adjusted, and water-tightness in the upper joint is secured by a sole-leather flap, which adjusts itself. Another advantage is that the valve stem is carried in a water-tight tube connecting with the masonry above. This removes all need of packing and saves in the matter of friction.

The valve, as put in by Colonel Merrill, was described by him as a modified copy of the low cylindrical valve of "Mornillon," which is used on the Central Canal of France, and which is described in the Annales des Ponts et Chaussées for 1886.

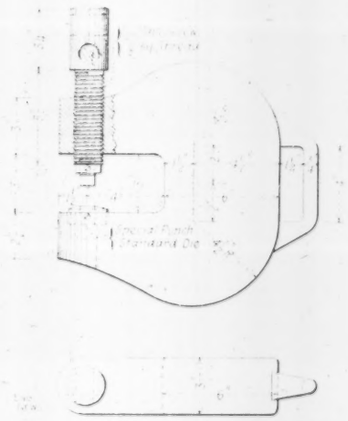
Very truly yours,

Cassius E. Gillette.

Land Title Building, Philadelphia, Pa., Feb. 24, 1908.

A Hand Punch for Making Rivet Holes.

SIR: It often happens in the erection of steel structures that numerous holes must be made in the field. Where compressed air is not available for power drills the hand punch illustrated in the drawing herewith is a time and money saver. As detailed in the drawing, the punch has a capacity of a 15/16-in. hole in 3/4-in. plate; it weighs about 80 lbs. complete.



A Screw-Operated Hand Rivet Punch.

The frame is made of cast steel containing about 0.4% of carbon, and is cast without cores of any kind. This gives the mold simplicity of form and a quite uniform cross-section, so that good castings are insured. The head is of machinery steel with a square thread of 1/4-in. pitch. The lower end of the head is bored out to 7/8-in. diameter, and the punch, which is special, is held in place by a 1/4-in. slotted headless set-screw. The same method

TABLE I.—AN ANALYSIS OF BUCHANAN'S COLUMN TESTS.

$$C = p\left(1 + \frac{e\,r}{r^2}\right)\left(1 + \frac{L^2}{18{,}000\,r^2}\right)$$

Test No.	Material.	Section.	Pins.	Efficiency of pin plates.* Pin Bearing.	Rivets.	Remarks on design.	L								Computed. C	Nominal yield-point of material
							r	e	c	L	c	A	I	p		
1	Iron	4 Zs. 1 Pl.	4 7/8 4 1/8	Data not given on drawing.			3.05	5.2	0.0	300	98	17.78	165.6	18,000	27,600	30,000
2	"	"	5 7/8 3 7/8	" " " " "			2.49	4.2	0.0	300	120	17.56	108.9	20,500	36,790	"
3	Steel	"	6 1/2 4 1/8	.74 .72	O. K. for 3/4" rivets.	O. K.	1.87	3.2	0.0	156	83.5	15.25	53	23,600	32,700	36,000
4	"	"	5 7/8 4 1/8	.67 .70	" "	O. K.	"	"	"	"	"	14.5	50.5	24,700	34,200	"
14	Iron	2 ls. 1 cov. pl.	4 1/2	.94	.83 x required No. of 7/8 in. rivets. Arrangement eccentric reducing efficiency greatly.		4.71	8.04	1.04	190	40.5	21.78	484	20,650	30,700	30,000
15	"	1 cov. pl. 4 ls. 2 web pls.	6	.89	O. K.	Good	6.51	†10.03	‡0.55	249	88.5	†30.17	1270	24,300	29,500	"
16	Steel	"	5 7/16	1.39	O. K.	Excellent	6.44	10.31	0.71	279	43.6	29.45	1220	28,900	37,300	36,000
17	"	Symmetrical 4 ls. 2 web pls.	5 7/16	1.50	O. K.	Good	3.72	5.1	‡0.8	168	45.3	15.9	218	‡25,000	36,100	"
18	"	1 cov. pl. 4 ls. 2 web pls.	5 5/16	0.97	Number of rivets sufficient if 7/8" dia., but arrangement is eccentric reducing efficiency greatly. Plates are too short.		†7.15	†11.23	‡0.62	249	35	†31.5	1662	26,500	32,000	"
19	"	"	"	"	Same as above. Eccentricity worse.		†7.15	†11.23	‡0.07	"	"	"	"	‡30,000	32,000	"

* Based on bearing and shearing values respectively 1.5 and 0.75 × compression values.
† Value obtained by writer, at variance with author's value.
‡ Value assumed by writer, to approximate eccentricity due to imperfect alinement.
NOTE.—All values in inches and pounds.

is used to secure the die in the frame. The dies used are standard dies from a power punch.

By providing a set of special punches, holes may be punched from 15/16-in. down. The average time required to punch 9/16-in. holes in 1/4-in. plate is about one minute each, with two men operating the punch. This is much faster than hand drilling and compares not unfavorably with power drilling.

An analysis of the stresses in the frame and head of this machine when working to full capacity follows.

If the ultimate shearing stress of the material to be punched is 45,000 lbs. per sq. in., the required pressure will be $\pi \times 15/16 \times 3/8 \times 45{,}000 = 43{,}100$ lbs. The maximum bending moment in the frame will be at section AB and is equal to $43{,}100\left(4 + \frac{6}{2}\right) = 301{,}700$ in.-lbs. The sectional modulus of the frame at this point is equal to $\frac{bd^2}{6}$ or $\frac{3 \times 6^2}{6} = 18$. The maximum fiber stress produced by the above bending moment is then $\frac{301{,}700}{18}$ or 16,760 lbs. per sq. in. To this must be added a tensile stress of $\frac{43{,}100}{18} = 2{,}390$ lbs. per sq. in., making the total maximum fiber stress 19,150 lbs. per sq. in. The bending moment in the frame at the back of the throat is four-sevenths of the maximum bending moment, so for the same fiber stress due to bending moment the sectional modulus of the frame at section CD must be $\frac{4}{7} \times 18 = 10.3$. Since $S = \frac{bd^2}{6}$, $\frac{6 \times 10.3}{3} = d^2$, whence d is found to be about 4½ ins., which is the required depth of the frame at the back of the throat.

The shear in the frame on the center line of the punch is $\frac{43{,}100}{3}$ lbs., or 14,365 lbs. per sq. in. for the top, and $\frac{43{,}100}{3\frac{1}{2}}$ lbs., or 12,310 lbs. per sq. in. at the die seat. The shear on the root of the thread in the head is 7,000 lbs. per sq. in., while the bearing pressure on the thread is 6,940 lbs. per sq. in.

The computed stresses may seem very high, but the punch is subject to no severe shocks during operation; and in case it breaks no lives are endangered thereby, while the monetary loss is small. All stresses are considerably below the elastic limits of the two metals used, so no permanent set or springing of the frame, should occur.

The threaded portion of the head should be well lubricated with a heavy mineral oil and graphite. The face of the punch should also be lubricated.

A. L. Campbell.

401 Ferdinand Ave., Detroit, Mich., Jan. 20, 1908.

Column Strength and Buchanan's Tests of Columns.

Sir.—Referring to the tests reported by Mr. C. P. Buchanan in your issue of Dec. 26, 1907, and your editorial comments on the same, the writer would like to present some results of an analysis of some of the test data. These tests show, at first sight, rather alarmingly low strength values for full-size columns as compared with specimen tests and usual designing values. A closer analysis, however, discloses reasons for the low values, which reasons are or should be recognized and provided for in designing structures. The reasons for the low values in these tests appears to be (1) eccentric application of loads; (2) improper design of end details; (3) relatively thin sections composing the columns; also, in certain cases, known defects in alinement of columns and of material composing same. When provision is made for these factors by applying the principles and formulas in common use, it is seen that the results are not so inconsistent nor alarming.

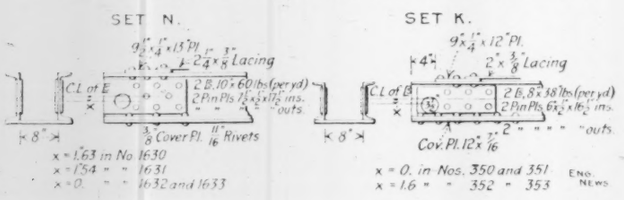
I attach a table (Table I.) covering the tests on those columns which had the better end details, which gives data intended to show the influence of the end details (see data under heading "Efficiency of Pin-plates"), and also gives the calculated base constant C derived from the test values for *average* unit stress at yield-point by application of a formula which considers the combined stress due to eccentric application of loading and the column reduction (deflection). The value C should represent approximately the maximum compressive fiber-

TABLE II.—ANALYSIS OF DETAILS OF COLUMNS, BUCHANAN'S TESTS.
Comparison with requirements of American Railway Engineering and Maintenance-of-Way Association's Specifications.

Requirements of A. R. E. & M. of W. Assn. Specifications.		1 Riveting at ends of column. Pitch ÷ diam. of rivet. Not over 4.	2 Riveting at ends of column. Length of riveting ÷ width of col. Not less than 1.5	3 Max. pitch of rivets. 5" for 1/2" 6" for 7/8"	4 Ratio $w \div t$ Not over 40.	5 Ratio $w' \div t'$ Not over 30.	6 Ratio $w'' \div t''$ Not over 50.	7 Length of tie-plate ÷ distance between riv. lines. Not less than 1.0.	8 Length of lattice c. to c. ÷ thickness of bars. Not over 40.	9 Width of outstanding leg ÷ its thickness. Not over 12.	10 Length of column between lattice rivets ÷ width of segment. Not over 80.	REMARKS.
Test	No. 1	No data	No data	No data	No. cov. pl.	Not applicable.	No tie pls.	No tie pls.	No lattice bars.	6.7	§Not applicable.	5" Zs' with 2¾" outstanding legs.
"	" 2	"	"	"	"	"	"	"	"	5.0	"	4" Zs with 2½" outstanding legs.
"	" 3	"	"	6" (?)	"	"	pin pls.	pin pls.	"	4.5	"	3" Zs with 2¼" outstanding legs.
"	" 4	"	"	6" (?)	"	"	"	"	"	4.8	"	3" Zs with 2¼" outstanding legs.
"	" 9	3.4 to 4*	1.3	5" except latt. part.	"	"	20.	2.2	27.	16.	4.0	.....
"	" 14	" *	1.25	6"	41.	(27.6)‡	41.	1.0	50.	3.4	7.9	.....
"	" 15	" *	1.0	6"	51.	34.5	57.	0.56	64.	13.4	4.8	.....
"	" 16	" *	2.1	6"	51.	34.	41.	1.2	60.	10.7	8.4	.....
"	" 17	" *	1.8	6"	No cov. pl.	18.	39.	1.2	46.	8.0	6.0	.....
"	18 & 19	" *	1.6	6"	51.	39.5	51.	1.1	50.	6.0	7.0	.....
Watertown Test....	N	About 8.7	Whole length (?)	About 6" (1⅛" riv.)	29.4	(22.7)‡	44.	0.9	abt. 35.	3.6	abt. 5.9	.....
" "	K	" 4.5	2.6	About 6" (⅝" riv.)(?)	25.	(22.3)‡	43.	0.8	35.	4.0	7.1	.....

w = transverse spacing of rivet lines in cover-plate.
t = thickness of cover-plate.
w' = transverse spacing of rivet lines in web-plates.
t' = thickness of web-plates.
w'' = transverse spacing of rivet-lines in tie-plates.
t'' = thickness of tie-plates.
*Size of rivets not known; ratio given for 7/8" and ¾".
†This ratio not given in Am. Ry. E. and M. of W. Assoc. specifications—taken from other specifications.
‡Ratio given is for depth of channels between flanges to thickness of channel webs.
§Restraining action of web indeterminate.
Underlined figures represent deficiencies.

TABLE III.—WATERTOWN ARSENAL TESTS.—UNSYMMETRICAL SECTIONS.—PIN CONNECTED. FROM A. S. C. E. TRANS., VOL. XVI., 1887, THEO. COOPER ON AMERICAN RAILWAY BRIDGES.



Set.	Test No.	Ratios $\frac{L}{d}$	Ratios $\frac{L}{r}$	Area of section.	Pin bearing.	Diam. of pin.	Ult. str.	Calculated C	Mode of failure.
N	1,630	29	75	47.6	9.3	3½ ins.	26,190	34,600	Deflection perp. to pins
N	1,631	29	76	17.2	9.3	"	28,150	37,200	" " " " " "
K	352	29	77	12.6	9.1	"	27,608	38,800	" " " Eccentricity .10 in.
K	353	29	77	12.8	9.1	"	30,596	43,000	" " " " " "
N	1,632	29	78	17.6	9.3	"	17,420	39,000	Pins in centre of channels.
N	1,633	29	78	17.7	9.3	"	17,240	38,400	" " " " " "
K	350	29	79	12.5	9.0	"	16,240	44,000	" " " " " "

NOTE.—All values in inches and pounds. * Approximately.

stress on the column at the yield-point. The formula is simply the Gordon-Rankine formula for pin-ended columns combined with the ordinary flexure formula for beams as follows: Let

P = total load on column,

C = base constant; yield-point of material in pounds per square inch,

p = average unit stress under load P, $= \frac{P}{A}$,

r = least radius of gyration,

v = distance from neutral axis to extreme fiber in compression,

e = distance from neutral axis of main column section to line of application of load (center of pins),

L = length of column between pin centers,

A = area of column section,

I = moment of inertia of column section.

Then,

$$p = \frac{C}{1 + \frac{L^2}{18{,}000\, r^2} \cdot \frac{P\, e\, v}{A\, r^2}}$$

from which is found

$$C = p\left(1 + \frac{e\, v}{r^2}\right)\left(1 + \frac{L^2}{18{,}000\, r^2}\right)$$

The working limit upon which the factor of safety should be based appears to be the yield-point, as that is the point below and up to which repeated applications of stress of the same kind may be made without rupture. Stressing to the yield-point might involve some permanent set and raise the original elastic limit, but the former would be inappreciable and the latter of no practical account. Any strength beyond the yield-point is of no value structurally. It may be thought that the column reduction factor is negligible in case of the shorter columns. In the writer's practice the column formula is applied to all columns on which its effect is appreciable, and as the intention is to equate the results of the tests to the equivalent base constant for design the column formula should be applied in all cases.

The writer found slightly different nominal values for r, e and A in case of columns of Tests 15, 18 and 19, as noted; he assumes that the values given for A were obtained from actual measurements of the material and has therefore used the values for yield-point as given in the test report. He also believes that the stress-strain diagrams as published would justify placing the yield-points for Tests 17 and 19 higher than established by Mr. Buchanan.

The values for C seem to compare quite satisfactorily with the nominal yield-point of the material, considering the deficiencies in details of construction of certain columns.

The columns of Tests 14, 18 and 19 would probably have given higher values had the pin-plates been riveted symmetrically about the neutral axes of columns or extended so far that the local bending effects on rivets and columns would have been eliminated. In the unsymmetrical sections, the pin-plates, tie-plates and lacing bars undoubtedly influence the position of the neutral axis and tend to lower the same, as suggested by Mr. Buchanan in his letter in Engineering News, Feb. 6, 1908. The improper counterweighting of column in Test No. 3 probably weakened the column, but the report states that the column deflected downward, whereas the counterweight effect would seem to be in the opposite direction.

In order to place a proper value on the results of the tests, a complete analysis of the construction details of the columns is necessary. It is, of course, axiomatic that the column reduction formulas employed in bridge specifications are intended to apply to columns which will fail as a whole rather than in their component parts or details, and such formulas are supplemented by rules for proportioning and detailing the columns to which they apply.

A tabulated analysis of the details of the columns is given in Table II. The analysis has been made to compare with the usual points covered by specifications and the requirements of the American Railway Engineering and Maintenance of Way Association for steel railroad bridges are shown for comparison with the values derived from the columns analyzed. These specifications have been chosen, as it was thought they represent pretty well the average practice.

Neglecting the Z-bar columns, which seem to be a special class of construction, reference to the table will show that the columns of Mr. Buchanan's tests all fail to comply in some point of construction or proportion with the requirements of the specifications. The deficiencies are seen to be most serious in Cols. 9, 15, 16, 18 and 19, which columns are built of very thin metal as compared with other dimensions. As a special instance, note column of Test 9, in which the ratio of width of longest outstanding leg to its thickness is 16. This column failed due to buckling of the outstanding legs of angles near center, which is clearly shown in photograph of column after failure, and it would seem that this ratio factor must have had a decided influence on the elastic strength. Similarly in columns 15 and 16 this ratio is high and the views of failure show in a marked degree the effect of same. The writer is inclined to think that the specified ratio limit should be reduced.

The effect of the relative thinness of the web-plates in columns of Tests 18 and 19 seems to be shown in the failure of Test 19, in which the buckling of the web-plate is apparent in the photograph. This may also be influenced by the eccentric riveting in the pin-plates.

The excessive length to thickness ratios of the lattice bars did not appear to be a source of weakness in the box columns. The appearance of column 17 after failure seems to indicate the possibility that stiffer latticing would have been beneficial.

Regarding the Z-bar columns, Tests 1 to 4, inclusive, it seems remarkable that these columns test so well, in view of the outstanding legs having no intermediate stays, especially in case of Tests 1 and 2. The lower strength shown in column 1 would seem to be explained in the comparatively lesser stiffness of this column, the outstanding legs being wider and the webs deeper than in the case of the other Z-bar columns, thus making the outstanding legs more flexible.

It seems reasonable to assume that the deficiencies in construction pointed out are largely responsible for lower strength values obtained.

Appended to Mr. Theodore Cooper's paper to the American Society of Civil Engineers, entitled "American Railroad Bridges," published in the Transactions of the society, Vol. XXI., July, 1889, is an abstract of about 140 tests of full-size columns tested at Watertown Arsenal. The tests covered both symmetrical and unsymmetrical sections (all wrought-iron), pin-connected and square-ended, and the column sections were the same as those in general use at the present day. The areas of columns varied from 4.5 sq. ins. to 21.5 sq. ins., L/r varying from 27 to 154. Compared with the P., C., C. & St. L. Ry. tests, the higher values obtained for ultimate strength of symmetrical sections in the Watertown tests are striking. The unsymmetrical sections are of especial interest at present, as they were tested with both central and eccentric loads. I attach a table (Table III.) giving the results as Mr. Cooper published them, together with sketches and data for the columns, and add a column showing the calculated maximum fiber-stress for the columns considering column action and eccentricity of loading, using the same formula as applied to the yield-point values in the P., C., C. & St. L. Ry. tests. It should, of course, be borne in mind that the results of Watertown tests are for ultimate strength. Attention is called to the deficient riveting of pin-plates in the Watertown columns; this undoubtedly influenced the lower average results for the columns having pins on center-of-gravity lines. Test No. 351 of set K has been purposely omitted as the data given for same appear to be incomplete.

The Watertown columns were relatively stockier columns than those of Mr. Buchanan's tests, although the riveting would not appear to be all that could be desired.

While on the subject it might not be amiss to mention that the Watertown tests seem to show a decided superiority in strength of two-segment symmetrical, latticed columns over box columns, I-columns and unsymmetrical (two-segment and one cover plate) columns. Mr. Waddell's columns, reported in your issue of January 16, 1908, were symmetrical section columns, and the results show the value of concentric loading and concentric riveting of properly designed pin plates. The writer understands that Mr. Waddell's elastic limit values are conservative estimates of the true elastic limit and that the yield-point was considerably higher.

Local injuries and defects of design and workmanship undoubtedly have a greater effect in reducing the elastic strength of columns than that of tension members, and consequently it would seem logical to place the value for the base constant for column unit-stresses somewhat lower than that for tension. In your editorial a value equal to 60% of the tension constant is suggested, based on the results of Mr. Buchanan's tests. In view of the analyses herewith presented it would seem that your conclusions should be modified, and that a very much higher value is warranted, certainly not less than 80%. The matter can hardly be satisfactorily settled until we have a thorough series of tests of full-size steel columns of approved modern design and parallel tests of full-size riveted tension members.

The writer does not wish to be thought as depreciating the value of Mr. Buchanan's tests; he simply desires to assist in giving them their proper weight and thinks it unfortunate that the deficiencies of construction were not pointed out together with their publication, so that erroneous conclusions as to the strength of columns in general might not be derived at this important period following the Quebec Bridge disaster. The greatest value of the tests possibly lies in the fact that they covered columns deficient in construction and show the serious results of such deficiency. That the publication of these tests will undoubtedly result in better designing is proof enough of their value and of the credit which Mr. Buchanan deserves. All must unite in commending Mr. Buchanan upon the admirable completeness of the test data furnished and Engineering News for the splendid representation of the same.

Respectfully,

New York City, Feb. 11, 1908. A. W. Carpenter.

Diagram for Correcting Subchord Lengths.

Sir: In staking out railway curves in yards where sharp curves are used, the accompanying diagram has been found very useful in finding the correction for subchord lengths in the formula $d = 100 \times \frac{\Delta}{D}$, in which

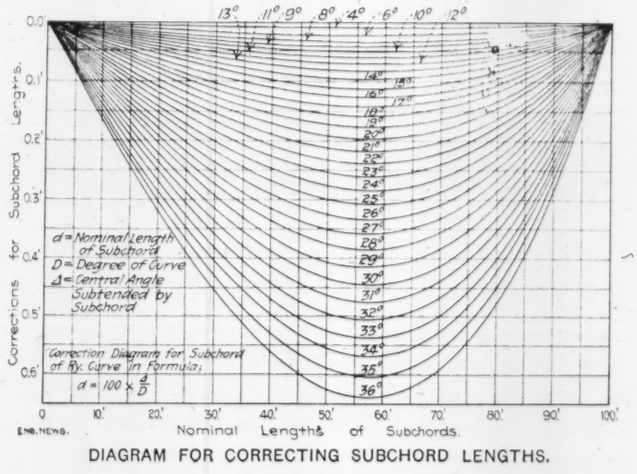
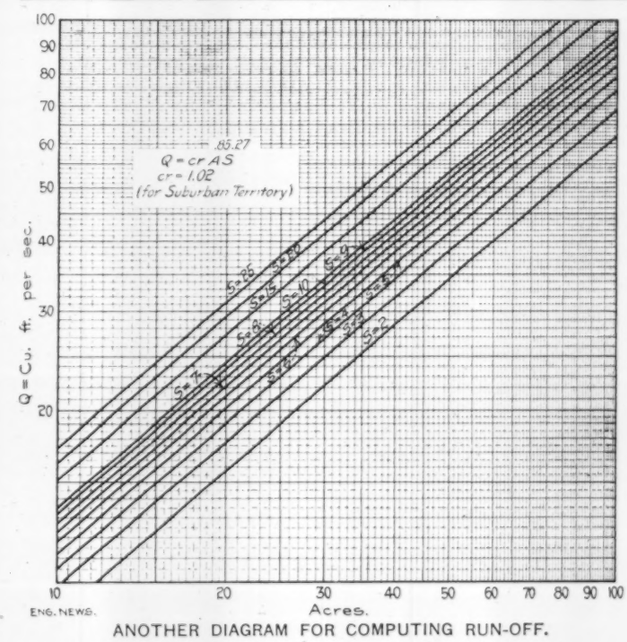

Corrections for Subchord Lengths.
Nominal Lengths of Subchords.
d = Nominal Length of Subchord
D = Degree of Curve
Δ = Central Angle Subtended by Subchord
Correction Diagram for Subchord of Ry. Curve in Formula; d = 100 × Δ/D
ENG. NEWS.

DIAGRAM FOR CORRECTING SUBCHORD LENGTHS.



ANOTHER DIAGRAM FOR COMPUTING RUN-OFF.

d = the nominal length of subchord, △ = the central angle subtended by the subchord and D = the degree of curve.

The use of the diagram is simple, either when the degree of curve and the length of subchord is given or the degree of curve and the central angle; for example let D = 29° and △ = 11° 36′. Then $d = \frac{11.6}{29} \times 100 = 40$ ft. = nominal subchord length, and from the diagram the correction to be added is 0.36 ft., being the horizontal coordinate of the intersection of the nominal subchord length with the curve marked 29°. If the actual length of the subchord be 40 ft., the correction for the formula is the same as above, 0.36 ft. and $\triangle = \frac{40 - 0.36}{100} \times 29 = 11° 29\frac{3}{4}'$.

Very respectfully,
C. M. Daily.

4240 Shaw Ave., St. Louis, Mo., March 6, 1908.

Another Diagram for Computing Run-Off.

Sir: In Engineering News of Feb. 27 you published a diagram for computing run-off by the McMath formula, as worked out by Mr. Samuel D. Bleich. I enclose a diagram worked out by me for computing run-off by New York diagrams.

I use a set of nine diagrams; three sets for the following values of *cr*: 1.64, 1.39, and 10.2. Each one of these sets is divided into three diagrams, one for an area of from 10 to 100 acres, the second for an area of from 100 to 1,000 acres and the third for an area of from 1,000 to 5,000 acres.

You will notice that the run-off can readily be taken from the diagram and that it is not necessary to go through the trouble of multiplying by a coefficient.

Very truly yours,
Alberto Schreiner,
Bureau of Sewers, Borough of Queens.

P. O. Box 45, Long Island City, N. Y., March 10, 1908.

The Replacement of the Erie Drawbridge Over the Cuyahoga River at Cleveland, Ohio.

Sir. Referring to the article on the Erie Cleveland drawbridge which appeared in your issue of April 2d, the proofs of which were unfortunately not read by us, Mr. Stuart, the Chief Engineer of Erie, desires to express his appreciation of the personal services of Mr. Fuller of the King Bridge Company in this work. Will you not kindly, therefore, make note of this in your columns.

Yours truly, Mason R. Strong,
M. Am. Soc. C. E.

7 Wall St., New York City, April 6, 1908.

Notes and Queries.

In the article "Tests of Gasoline and Kerosene Engines with Alcohol Fuel," by S. M. Woodward, in our issue of March 12, the captions of the indicator card diagrams Figs. 4 and 8 were interchanged by an arror.

In the article on a "Tunnel Inspection Car: Erie R. R.," in our issue of April 2, it was stated that the car was constructed for use on the work in the new tunnels of the Erie R. R. under Bergen Hill, N. J. The more exact statement is that the car was built for inspecting the old Bergen Hill Tunnel after blasts in the new open cut (with four short tunnels) which is being constructed parallel to the older tunnel.

Our attention has been called to an error in the titles to two of the cuts illustrating the article on the sewage purification works for Berlin - Wilmersdorf, Germany, published in our issue of March 19. The view marked Fig. 6 showed the upper or preliminary settling tanks, with the percolating filters in the distance, and the front page view showed the final settling tanks to which the effluent from the percolating filters passes.

In the article on the hydraulic dredge of the Lincoln Park Commission, in our issue of Feb. 27, it was stated that the machine worked 122½ days (of 24 hrs.) with a total excavation of 457,242 cu. yds., the average being 426 cu. yds. per hour. Question has been raised as to the accuracy of these figures in view of the fact that the average named would give a much greater output for the total number of hours. We are informed by the engineer, however, that the figure given for average output refers to the time during which the dredge was actually pumping, so that there is really no discrepancy in the figures.

APPARATUS FOR PREVENTING THE FORMATION OF COHERENT SCALE IN BOILERS.*

By M. GOLSDORF.†

Considerable amounts of scale are always deposited in boilers at the places where the feed water enters, no matter whether it enters directly into the boiler after going through the feed valve, or whether it first passes through a certain length of tube after going through the valve. At these places the water coming from the injector suddenly loses the greater part of its velocity, and its temperature is very quickly raised from about 212° F. to nearly 392° F.

There is no doubt that the deposit of scale is due to the combined effect of the two phenomena mentioned, and it may logically be proposed to increase the effect of both so as to make the water, as soon as it enters the boiler, precipitate the greater part of the impurities it contains. This would make it possible to collect the precipitate in a receptacle easy to clean.

Figures 1, 2 and 3 show an appliance which has been fitted to several express locomotives of the Austrian State Ry. (series 206). Two cast-iron receptacles, each made in two pieces for convenience of fitting, are placed one on each side of the set of tubes, so as to be completely immersed in the water; rectangular openings are provided in the upper side opposite to the opening through which the feed water enters.

At the end of each run (about 100 miles), the mud-cocks at the bottom are opened, the injectors having previously been turned on so as to keep up a strong pressure in the receptacles and blow out the deposits.

The following results have been obtained with this device:

The water used for the locomotives of series 206 is such that, in order to prevent priming, the boilers had to be washed out every eight days; the locomotives fitted with this appliance run 14 days before it is necessary to clean the boilers. Hard scale is no longer formed, but only soft mud which is removed without difficulty.

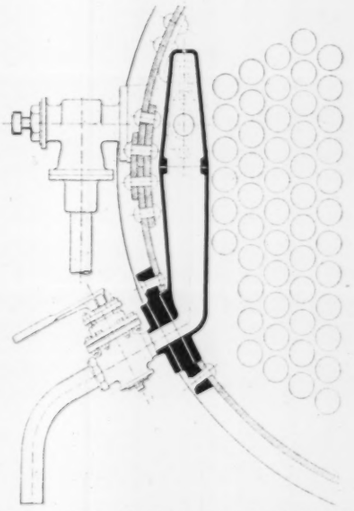


Fig. 1. Partial Section of Locomotive Boiler, Showing End Section of Scale Preventing Device in Position.

The first trials were made at Mr. Alex. Friedmann's works at Vienna, on a stationary boiler of the locomotive type, having a heating surface of 36 sq. meters (387.52 sq. ft.). The appliance used consisted of a tube 1 meter (3 ft. 3⅜ ins.) long, of oval section; the vertical axis was 170 mm. (6 $^{11}/_{16}$ ins.) and the horizontal axis 80 mm. (3 $^{5}/_{32}$ ins.) in length. Fig. 3 is the reproduction of a photograph showing the deposit found below the rectangular openings through which the water passes, after 30 hours' use of the trial apparatus.

The examination of this deposit showed that the apparatus had not only induced the separation of the solid particles suspended in the water, but had also caused the precipitation of the dissolved salts which produce scale, such as calcium and magnesium carbonate and calcium sulphate. Chemical analysis showed that these three substances were present in the deposit in about the same relative proportions as in the feed water.

The most important point is the precipitation of the magnesia, which no previous water-softening apparatus was able to remove; now it is well known that it is the presence of this substance which induces the calcium salts to form a hard and coherent scale.

*From the bulletin of the International Railway Congress Association for October, 1907.
†Chief Councilor, Austrian State Ry.

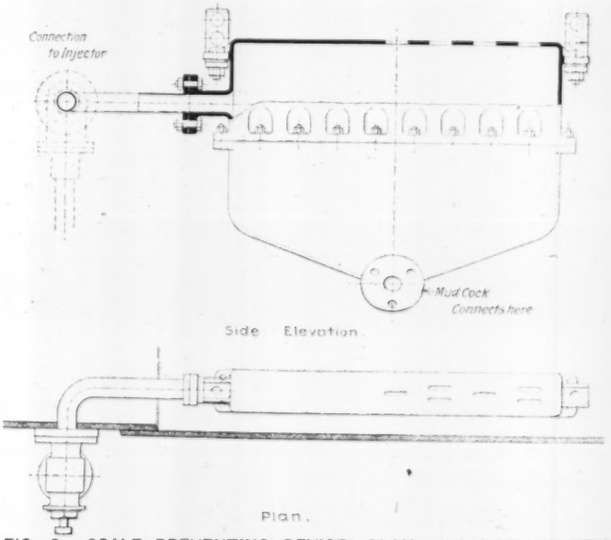


FIG. 2. SCALE PREVENTING DEVICE; PLAN AND SIDE ELEVATION.

Fig. 3. First Model of Scale Preventing Apparatus, Showing Deposit in Interior.

A SUMMARY OF TESTS OF LARGE COLUMNS: APPENDIX 13 TO THE QUEBEC BRIDGE COMMISSION'S REPORT.

One of the most valuable portions of the Quebec Bridge Commission's work is a study of all the large size column tests that have ever been made. The study is summarized in three diagrams, which we reproduce herewith, and in Appendix 13 of the Commission's Report. This Appendix is reprinted below, practically in full.

The report itself and the first eleven appendices (of 19) were abstracted very fully in our issue of March 19, 1908. Since then the Commission has presented four more appendices to the Government, and the remaining four will probably follow soon. We expect to present in future issues abstracts of all the appendices not included in our issue of March 19; for the present we give only the summary of column tests, Appendix 13, because of the general attention now directed toward the subject of column strength.

The fall of the Quebec Bridge being found due to the failure of certain lower-chord compression members, the Commission considered it necessary to study the question of why these chords failed. It was known that the load which they carried at the time of failure was not only below the strength ordinarily attributed to steel columns, but below the load which the designers intended them to bear with full safety in the completed structure. Roughly speaking they were carrying a load of only 18,000 lbs. per sq. in., while the greatest service load would amount to 24,000 lbs. per sq. in. according to the original intention, and 27,000 lbs. per sq. in. according to the later decision of the designers. It was of first importance to the Commission to determine whether and how far the designers of the Quebec Bridge were justified by past experience in imposing such high stresses; the second problem was to determine why these particular compression members failed at a load of 18,000 lbs. per sq. in. whereas other columns, in test, have showed much higher strengths.

The first of these two problems, discussed in Appendix 13, required a study of all obtainable column tests.

In examining the records, a process of elimination was adopted, the object being to select those tests which most nearly corresponded to the Quebec Bridge conditions. The following are the considerations upon which the selection was made:

(1) No tests on solid sections were used, because the bridge chords were built-up members and apparently failed from weakness of connecting details, the conditions being absolutely different from those existing in a solid section.

(2) No tests on sections that have been proved defective were used, except that certain of the Buchanan tests, which were published in 1907, have been selected on account of the large sections of the test pieces, although these were not of the most approved design.

(3) No tests on members whose failure was caused by defects in the testing apparatus were used. In the earlier tests special ends were fitted to many of the test columns, with unsatisfactory results.

(4) It was intended to exclude all tests on members having less than 10 sq. ins. area, but some tests on sections having areas between 7½ and 10 sq. ins. have been included.

(5) When the ratio $\frac{l}{r}$ for any column exceeded about 120 the test results were not used.

RECORDS OF COLUMN TESTS.

The records consulted were:

I.—J. M. MONCRIEFF (Trans. Am. Soc. C. E., Vol. XLV., 1901).—This paper, which was written by an English engineer, contains perhaps the most complete compilation of column test data that has ever been published. It was consulted for reference to original authorities. The records contained in it show that there were practically no English or European tests that would not be excluded by the fourth consideration above mentioned.

II.—"TESTS OF METALS".—This is the official record of all tests made at the United States Arsenal at Watertown, Mass. The complete file of these volumes, publication of which began about 1881, was examined. No tests of interest were found in any volumes issued after 1884. The results from tests on wrought-iron columns of the Phoenix, box, and latticed-channel types have been selected. The results of 90 of these tests have been used. The specimens varied in cross section from 7 sq. ins. to 22 sq. ins., there being 6 with areas between 20 and 22 sq. ins. and 14 with areas between 15 and 20 sq. ins.

III.—G. BOUSCAREN (Trans. Am. Soc. C. E., Vol. IX., 1880).—The tests recorded in this paper were made between 1875 and 1879 in connection with the building of the Cincinnati Southern Railway. They included tests on wrought-iron columns of the box and latticed-channel types. In all 9 tests were selected for use. This series of tests has possibly had more influence upon the detail of bridge design than any other series that has been made as the rejection of various types of columns and the adoption of various modifications in detailing directly resulted from it. The small number of tests that have been selected for this record shows how greatly the tests were needed at the time. The cross section varied from a minimum of about 11 sq. ins. to a maximum of about 14 sq. ins., with the exception of one box column which had an area of 26.06 sq. ins. The metal used developed an ultimate strength of between 52,000 and 55,000 lbs. per sq. in., Mr. Bouscaren's specification of 1875 calling for an ultimate strength of 60,000 lbs. per sq. in. in tension.

IV.—CLARKE, REEVES AND CO. (Trans. Am. Soc. C. E., Vol. XI., 1882).—This firm, which was the predecessor of the Phoenix Bridge Company, published in this paper the results of a series of tests on Phoenix columns which were made for them in 1879 and 1880 at the Watertown Arsenal, the material being wrought iron. There were 22 tests in all. It was found necessary to alter the "breaking load" on some of the shorter columns, as an examination of the diary of the tests showed that real failure had occurred considerably before the metal managed to escape from the following up of the machine. Clarke, Reeves and Co.'s specification of 1871 calls for iron of an ultimate strength of from 55,000 to 60,000 lbs. per sq. in. Twenty of the columns had a sectional area of about 12 sq. ins., and two a sectional area of 18.3 sq. ins.

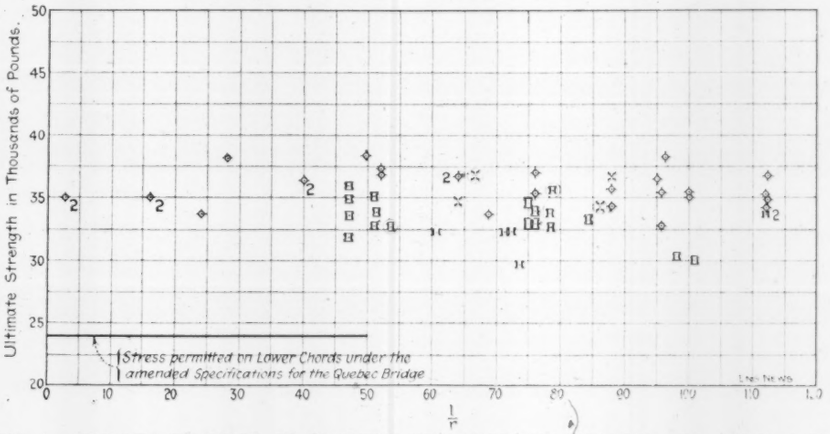


FIG. 1. RESULTS OF TESTS OF FLAT-END WROUGHT-IRON COLUMNS OF LARGE SIZE, 1873-1907, COLLATED BY THE QUEBEC BRIDGE COMMISSION.

Failure Load Plotted on Value of l/r.

(The figure 2 indicates that two tests on the same type of section gave substantially identical results.)

V.—C. L. STROBEL (Trans. Am. Soc. C. E., Vol. XVIII., 1888).—The tests recorded in this paper were made in 1887 upon columns of H-shape built up of four Z-bars with a latticed web. The material was wrought iron and the results of nine tests have been used. The sectional area in each case was between 9 and 10 sq. ins.

VI.—J. G. DAGRON (Trans. Am. Soc. C. E., Vol. XX., 1889).—This series of eight tests, all of which have been used, was made in 1884-5. The columns were of the latticed two-channel type, the channels being built-up. The material was high steel, the ultimate strength being given at 84,000 lbs. per sq. in. and the elastic limit at 53,000 lbs. per sq. in. The columns were between 8 and 14 sq. ins. in cross-section.

VII.—PROF. W. H. BURR. "The Elasticity and Resistance of the Materials of Engineering."—In this book there is given a full resume of column-test data, including four tests on Phoenix columns made in 1873, the results of which have been used. The columns were between 8 and 14 sq. ins. in cross-section.

VIII.—C. P. BUCHANAN (Engineering News, Dec. 26, 1907).—In this paper are given the results of 19 tests made between 1888 and 1900, the sections of the specimens varying from about 14 sq. ins. to 33 sq. ins., these being the largest columns that had been tested previous to the investigations made in connection with our inquiry. The results were not made public until the date above mentioned and were not available for use of the Quebec Bridge designers. Twelve of the specimens were of wrought iron, three of Bessemer steel and four of open-hearth steel, these last four being of the grade known as "structural steel," which is at present in general use for bridge work. Only six of the specimens were strictly symmetrical. The columns were of the "H," two-channel, and upper-chord types. All the results have been used, although on account of unsymmetrical sections, and eccentric loading in several cases, high ultimate strength was not to be expected.

IX.—J. A. L. WADDELL (Engineering News, Jan. 16, 1908).—This paper gives the results of six tests upon structural steel columns of the two-channel type. The tests were made about 1907. All of the results have been used, the column sections being 17.44 sq. ins. in area. The results of the tests on nickel-steel columns which were made at the same time have not been included.

The results of 176 tests in all have been plotted, the cross-section of the largest column being less than 33 sq. ins. in area, and that of the smallest greater than 7½ sq. ins.; three columns had cross-sections greater than 30 sq. ins., 9 greater than 25 sq. ins., 16 greater than 20 sq. ins., and 20 greater than 15 sq. ins. The results of the tests are divided into three groups, viz.: Flat-ended wrought-iron columns, pin-ended wrought-iron columns, and pin-ended steel columns. [The plottings of these three groups are reproduced herewith as Figs. 1, 2 and 3.—Ed.]

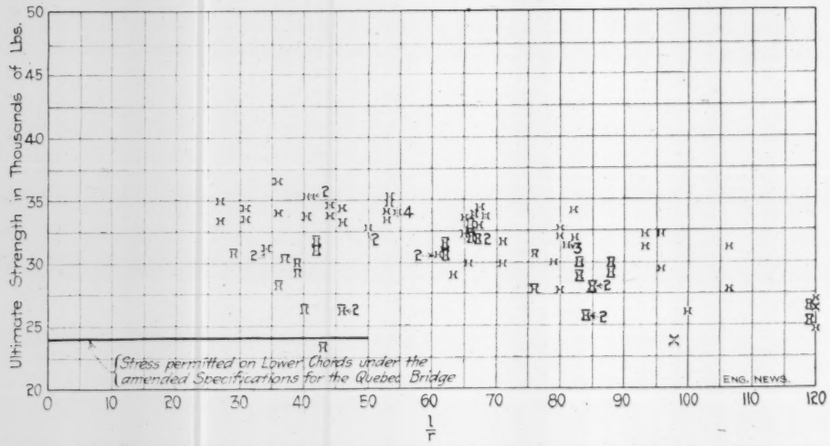


FIG. 2. RESULTS OF TESTS OF PIN-END WROUGHT-IRON COLUMNS OF LARGE SIZE, 1873-1907, COLLATED BY THE QUEBEC BRIDGE COMMISSION.

Failure Load Plotted on Value of l/r.

(The figure 2 indicates that two tests on the same type of section gave substantially identical results.)

CONCLUSIONS FROM THE PRIOR TEST DATA.

The following conclusions may be drawn from this study:

1. Very few tests have been made on full-sized steel columns, and some of those that have been made are upon unusual grades of material.

2. The experiments upon which modern practice is largely depending were made at least twenty years ago,

and upon a grade of material which is not now in use in bridge construction.

3. The decrease of strength with increase of the ratio $\frac{l}{r}$ is, in the case of flat-ended, wrought-iron columns, not clearly discernible on the plotting of the test results [Fig. 1].

4. This decrease is discernible on the diagram in the case of pin-ended, wrought-iron columns [Fig. 2], but it is not nearly so rapid as the decrease indicated by the column formula adopted in the amended specifications for the Quebec Bridge.

5. It is evident from the particulars of many tests that the size and strength of the pin used have an appreciable effect on the results obtained, but the amount of this effect has not been determined.

6. The relation between the strength of a column as determined by test and as calculated by formula varies greatly.

7. No series of tests have been made to determine the relative stresses in the various parts of a built-up column.

8. The strength of a column is greatly affected by what have been considered minor features in the end details.

9. A compression member of usual design and dimensions cannot be expected to develop an ultimate strength much greater than about one-half of the ultimate strength of a tension member made from the same material.

10. No tests have been made on columns of the form of the Quebec lower chords nor on any having more than about $\frac{1}{30}$th of the cross-section of these chords.

That the results of laboratory tests should not be rigidly followed in field practice is axiomatic, but the extent to which they can be safely accepted is a matter of judgment. During the last 25 years, a failure similar to that of the Quebec Bridge has been, we believe, unknown, and as compression members designed in accordance with the results of the Bouscaren tests have been uniformly successful, little doubt existed in the minds of practicing bridge engineers concerning them.

There is no definite evidence to show that either Mr. Cooper or Mr. Szlapka ordered any investigation to be made of the test data that were available, and when the comparative magnitude of the undertaking is remembered it is difficult to explain their failure to check their conclusions on the Phoenix testing machine, which was at their disposal.

It should be remembered that, previous to the Quebec disaster, the insufficiency of the existing knowledge of column action had been widely recognized, and programs for additional testing were under consideration both by the American Society for Testing Materials and by an independent committee of prominent engineers, acting in co-operation with the officers attached to the United States Arsenal at Watertown. It is generally felt that modern bridge work has grown to such dimensions that further investigations are desirable.

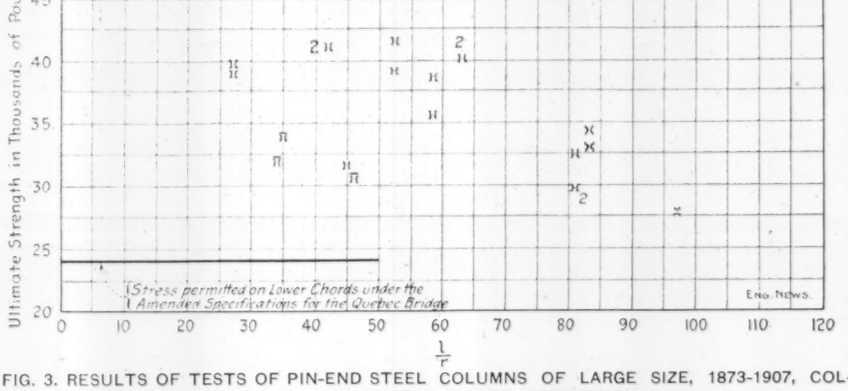


FIG. 3. RESULTS OF TESTS OF PIN-END STEEL COLUMNS OF LARGE SIZE, 1873-1907, COLLATED BY THE QUEBEC BRIDGE COMMISSION.

Failure Load Plotted on Value of l/r.

(The figure 2, indicates that two tests on the same type of section gave substantially identical results.)

THE MISSISSIPPI RIVER may have a 14-ft. depth low water channel from Cairo south by dredging alone, according to unofficial statements regarding a report drafted by the Mississippi River Commission. At present a depth of 8 to 9 ft. is maintained at low water by dredging the shallow reaches between pools. Tests have been carried on this winter which indicate that by this system of dredging the depth over the bars between pools can be increased to 14 ft.

THE INDIAN CREEK WATER SUPPLY SYSTEM OF THE PENNSYLVANIA RAILROAD.

By J. W. LEDOUX,* M. Am. Soc. C. E.

By far the most elaborate and comprehensive system of water-works ever undertaken for a like purpose has recently been put into operation for the Pennsylvania Railroad along its lines between Philadelphia and Pittsburg.

Up to this time the water supply along the Pittsburg, Southwest and Monongahela divisions of the Pennsylvania Railroad was, as has been so common with other railroads, very precarious. Many of the streams utilized were so highly charged with sulphuric acid from coal mine drainage that an ordinary drought would so concentrate the corrosive qualities of the water as to render the locomotives using it unfit for service in a few weeks. During the dry summer and fall of 1904, before the new water supply was introduced, the loss from this cause and the consequent inability to move trains, ran into the millions of dollars. President A. J. Cassatt had foreseen the great danger to the railroad, due to neglect of its water supply, and with his accustomed vigor had undertaken comprehensive measures to install a water supply of good quality and ample quantity for the entire railroad system. The Indian Creek system herein described is one of the many water-works projects between Philadelphia and Pittsburg successfully carried out and built under his regime since 1903. On account of their large experience in water supply, The American Pipe Manufacturing Co., in 1902, was selected to make an investigation of the water supply conditions of the district including the Pittsburg, Southwestern and Monongahela Divisions, and upon consideration of the needs of the railroad and all the practical and available supplies, Indian Creek was finally recommended as the most feasible, and The American Pipe Manufacturing Co. was engaged to make plans, purchase land, develop the water supply and construct the entire water system. Under these arrangements work was begun in the early part of 1903.

Indian Creek is located in Fayette County, Pennsylvania; rises near Ligonier and flows westerly to the Youghiogheny River, into which it empties at the village of Indian Creek, on the Baltimore & Ohio R. R. This stream is one of the very few streams in that vicinity which is uncontaminated by coal mine drainage, and it has for many years been recognized as a valuable source of water supply.

The drainage area of Indian Creek above the dam is approximately 109 square miles. The entire territory is sparsely populated, the only material settlements being Donegal, Roaring Run, Jones' Mill, Indian Head, Normalville and Mill Run, and none of these villages has more than two or three dozen houses, and the entire population of the drainage area does not exceed 25 persons per square mile.

With the storage provided the stream is estimated to yield in the driest season up to about 15,000,000 gals per day.

A reservoir holding approximately 231,000,000 gallons was constructed at a point on Indian Creek, at Elev. 1250. Eleven distributing reservoirs, with a combined capacity of about 49,000,000 gals., bring the total storage capacity up to 280,000,000 gals. The reservoirs are connected and the various railway water supply stations are supplied by 135.25 miles of 36 to 10-in. cast iron pipe, as shown by the accompanying map.

The Indian Creek dam was built of a solid gravity section, founded on bed sandstone rock. Its maximum height is 40 ft. and its length is 763 ft. The up-stream and down-stream faces of the dam were composed of large rubble masonry, with horizontal and vertical joints and rock faces. The space between these facings was composed of 1:2:5 Portland cement concrete having embedded in it as large a proportion as possible of stones averaging about ½ cu. yd. in size. The stone for all purposes was obtained from a quarry located close to the south end of the dam. The stone for concrete was all that passed through a 1½-in. screen, while such as passed through a ½-in screen was used with that produced by sand crushers to make up the sand used in the masonry. The concrete was mixed by means of Smith and Ransome mixers; the batches and all the large stones were handled by means of derricks and tram cars running on tracks along the side of the dam.

The excavation for the south end of the dam was first completed, and the lower portion of the dam was then constructed to a point near the center of the stream, and then by means of coffer dams the stream was spanned and the water compelled to flow through the 36-in. discharge and 48-in. blow-off pipes. These ordinarily took care of all the water, and on one occasion when their carrying capacity was insufficient, the water was allowed to run over the top of the unfinished dam, which it did without damage or serious inconvenience. The dam was finally covered with a 1½-ft. sandstone coping.

There were several parts of the foundation rock which by test were found to be more or less porous. The method of testing and correcting this difficulty was as follows: With the steam drilling machines holes were drilled to the depth of 10 to 20 ft. below the bottom of the foundation, and with hand pumps water was forced into these holes under pressure, the suction pipe being kept in a barrel maintained constantly full. While pumping the water could be seen flowing out from the cracks in the rock. Then pure cement was stirred into the suction barrel until the grout thus formed became as thick as could be pumped readily, and the pump was not stopped until the increased pressure made it too laborious to longer move the pump levers. In some cases the holes were not more than 4 ft. apart. Three or four days after a series of holes was treated in this manner, a second series was drilled parallel to the first row, breaking joints with same, and these were treated in a like manner. As a general thing it would be difficult to pump grout into the second series, because the spaces in the rock would be filled up with grout from the previous line of holes.

After the dam was completed and full of water it was found that there was no noticeable leakage from below the foundation but during the first winter, which was very severe, several vertical temperature cracks took place in the masonry. These, although not serious, were grouted by a method similar to that used in the foundation, and in the spring they had disappeared from sight, and did not again reappear.

The 36-in. line between Indian Creek dam and Connellsville proved to be a very difficult piece of construction. The first plan was to lay the pipe line along the Youghiogheny River side of the Baltimore & Ohio Railroad, but the railroad company made strenuous objections to this posi-

*Chief Engineer, The American Pipe Manufacturing Co., 112 North Broad St., Philadelphia, Pa.

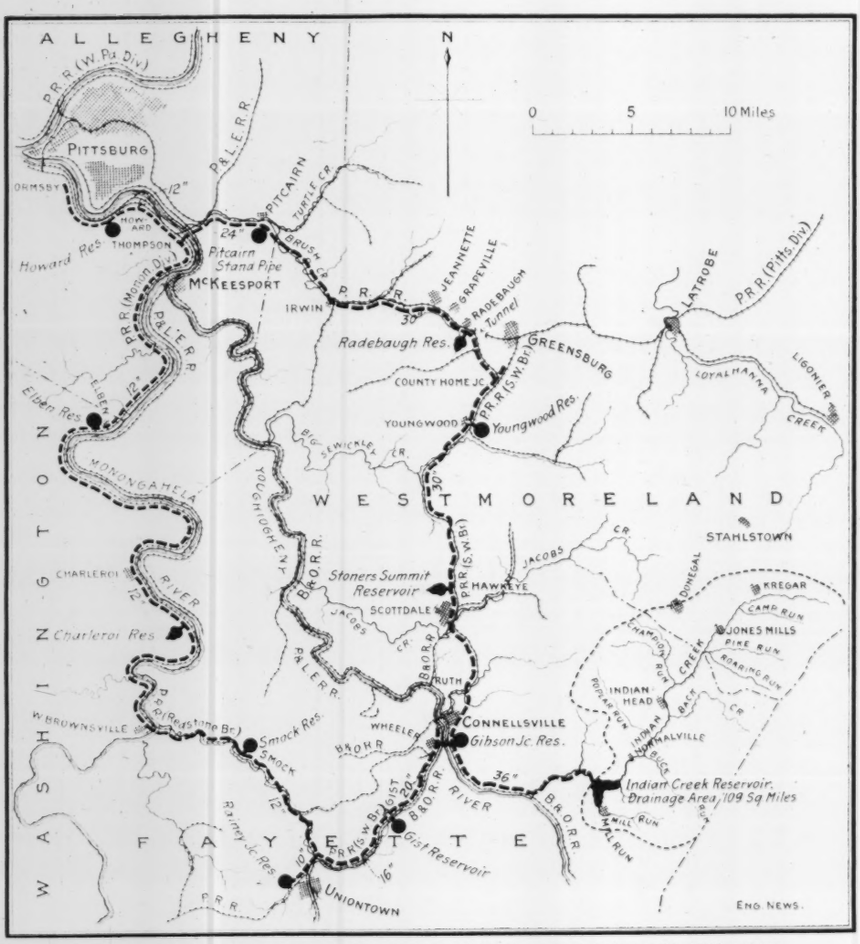
tion, and the matter was finally compromised by constructing the line on the side of the mountain, to the east of the railroad. On account of the roughness of the country and the inaccessibility of the pipe line it was necessary to build a tram road from Indian Creek dam the entire distance to within two miles of Connellsville. In some cases the mountain slopes were very precipitous, inclining in several places as much as 48° from the horizontal. Along this pipe line landslides had been frequent, and to obviate the danger from this source it was necessary to build just below the pipe line a number of rubble masonry retaining walls bedded on solid rock. Wherever slides appeared likely to take place the pipe was laid on the solid rock ledge, which made it necessary frequently to excavate to great depths, in some cases as great as 30 ft.

At Radebaugh, to keep below the hydraulic grade line, a tunnel about 2,100 ft. long was constructed. This was circular in section, and lined with about 12 ins. of concrete, and a 30-in. cast-iron pipe was laid therein.

Where streams draining mines had to be crossed the pipes were laid in and surrounded by concrete to prevent corrosion.

Over the Monongahela, at Port Perry, the 20-in. pipe line was laid on structural streel brackets, bolted to the outside of the bridge structure. The pipe was made of steel with Van Stone flanged joints, and afterwards covered with 3 ins. of hair felt. Although the length of this bridge was over a thousand feet, no expansion joints were put in, but the stresses due to temperature were amply taken care of by the tensile strength of the pipe itself and its joints, the maximum stress due to this cause not exceeding 20,000 lbs. per sq. in. At West Brownsville, on the Monongahela Division, the 12-in. pipe was laid below the bed of the river, the excavation being done by dredges, and the joints being of the flexible type similar to the Ward joint, were made by means of divers.

At the only available place where the first distributing reservoir could be constructed (Gibson Junction) at a proper elevation the material and foundations were found to be unsuitable for earth embankment construction. The ground here was composed of shaley sandstone rock, and the surface sloped at a grade of about 10%. The design adopted consisted of a heavy rock excavation on the high side and sufficient at the low side of the reservoir to secure a satisfactory footing for masonry walls. These were built of a top thickness of 3 ft. with vertical face against the water, and back slopes of 1 to 4. The material consisted of Portland cement concrete, 1:3:5. Reinforcing Johnson bars were used in the concrete to prevent, as far as possible, temperature cracks. On the high side of the slope the excavation was carried considerably wider than the neat line of the outside of the wall, so as to provide room for a pipe drainage system, and thus make it unnecessary for the wall to act as a dam in case the reservoir were emptied. The top portion of this wall was formed into a neat cement coping, 8 ins. thick, projecting 2 ins. toward the reservoir.



MAP OF INDIAN CREEK WATER SUPPLY SYSTEM, PENNSYLVANIA RAILROAD.

Reservoir Capacities and Elevations.

Reservoir.	Capacity, gals.	Elev., ft.	Reservoir.	Capacity, gals.	Elev., ft.
Indian Creek	231,000,000	1,250	Howard	2,000,000	887
Gibson Junction	6,500,000	1,222	Gist	2,800,000	....
Stoner's Summit	13,670,000	1,200	Smook	2,000,000	....
Youngwood	1,000,000	....	Charleroi	7,235,000	....
Radebaugh	8,500,000	....	Elben	2,000,000	....
Pitcairn*	1,760,000	....	Rainey	2,000,000	....

Total number of gallons, 280,465,000.

*Steel tank, 100 ft. in diameter, 30 ft. high.

The length of the various sizes of pipe, in miles, is as follows: 36-in., 17.06; 30-in., 32.17; 24-in., 3.29; 20-in., 7.74; 16-in., 4.42; 12-in., 66.30; 10-in., 4.27.

DISTRIBUTING RESERVOIRS.—These were of two general types. In the first type the reservoir is formed by an earth dam having a top width of 12 ft. and outer and inner slopes 1½ to 1. At the foot of the up-stream slope is sunk a puddle trench 6 ft. wide, extending down to impervious material. The up-stream portion of this puddle trench is filled with 2 ft. of concrete; and the down-stream 4 ft. with compacted clay, laid in thin layers, incorporated at the surface with the rolled embankment. The concrete is then connected with the slope concrete, which is 12 ins. in normal thickness, and laid to within 3 ft. of the flow line. From this point to 2 ft. above the flow line is laid a masonry slope wall 18 ins. in thickness. The best material was selected from the excavation for the up-stream portion of the embankment, and the whole was compacted in layers less than 6 ins. in thickness, by means of heavy grooved rollers, run by steam. It would seem that this type of construction, whereby a water-tight masonry curtain covers the entire up-stream slope of the embankment and extends down to impervious material, has decided advantages over the old-fashioned method of constructing a core wall at the center of the embankment.

The other type of reservoir is formed of an earth embankment lined on the water side with 12 ins. of concrete, and the outer slopes are either sodded or seeded. The bottom of the reservoir is covered with 16 ins. of compacted clay, laid in thin layers and covered with 3 ins. of concrete, connected with the slope concrete. The flow line in both cases is kept at least 3 ft. below the top of the embankment.

REGULATING VALVES AND SCREEN POTS.—In order to maintain the reservoirs full of water, and prevent overflow, Simplex controlling valves are provided on the inlet mains. (See article, also by the writer, in Engineering News of March 9, 1905, for illustrated description of this type of controlling valve.) There is also provided on each reservoir outlet main a large screen pot, the screens of which are made of ¼-in. mesh wire.

GATE HOUSES.—The gate houses are all built of the same general type. The walls are of broken range masonry, having 12-in. and 6-in. rock-face stones, laid with vertical and horizontal joints and regular alternate pattern. The roofs are of red tile and the floors are all concrete on steel I-beam construction.

RELIEF VALVES.—Near the points of consumption on the distributing system of pipes large relief valves are provided with either 6 or 8-in. opening, and in many cases the railroad water tanks are provided with relief valves on the supply pipe within the tank.

METERS.—At several points along the supply mains are provided meters of the Venturi principle, and by this means a close count is kept of the water furnished to every portion of the system. Each meter is provided with a rate of flow dial and a six-figure register dial, and they are read once per week and observed whenever advisable to determine the rate of flow at particular times.

The rate of flow dial has the appearance of a large pressure gage with a hand pointing to figures representing the rate of flow in gallons

per 24 hours. A six-figure meter register gives a summation of the total amount of water which has passed through the main, the same as an ordinary house meter. The essential parts of the meter register consist of a U-tube containing mercury. Connections with the tops of this U-tube are made with the full and contracted sections of the Venturi tube, so that the difference in the level of the mercury in the U-tube will indicate the difference in pressure in the throat and full section of the Venturi tube, and this difference furnishes an exact measure of the rate of flow through the Venturi tube. Resting on the mercury in the lower leg of the U-tube is a float having attached to it a fine nickel wire, which passes up through an opening in the top of the U-tube to a sheave, and is counterweighted. Rigidly attached to this sheave is a cam and also a flow dial. By means of a water clock a tappet is made to touch this cam once every two minutes so that the length of stroke of the tappet is dependent upon the position of the cam. By means of suitable gearing the dials of the six-figure meter register are moved in proportion to the length of stroke of tappet, and thus they indicate the exact quantity of water passing through the Venturi tube. The uniformity of operation of this clock is produced by means of a pendulum and pin escapement. The amount of water required is inappreciable, being less than a pint per minute. This device being continuous in operation, eliminates the necessity of winding and has a great advantage over an electrical self-winding clock, in that the latter cannot be depended upon when used in a place which is in the least subject to dampness. The value of large meters in the operation of water pipe lines is incalculable and they should never be omitted from a gravity system of this character.

The entire work above described was constructed by The American Pipe Manufacturing Co., 112 N. Broad St., Philadelphia, according to its reports, plans and engineering supervision, all matters appertaining to the Pennsylvania Railroad being subject to the revision and approval of Mr. Jos. T. Richards, Chief Engineer Maintenance of Way.

FOUR EXPLOSIONS have been reported recently. Three Bulgarians were badly hurt March 30, in an explosion of dynamite at the site of the Shoshone irrigation dam at Cody, Wyo. The accident is attributed to the ignorance of the foreigners as to how the powder should have been handled. A powder magazine of the University of Minnesota exploded, on April 4, wrecking the building and breaking many windows in the law, chemistry and mining buildings. The boiler of an engine, on a freight train at Hillgirt, on the Spartanburg Branch of the Southern Ry., exploded on April 4. The engine was demolished, several cars were derailed and the boiler was thrown 50 ft. The engineer and fireman were killed. A locomotive attached to a work train on the Adirondack division of the New York Central & Hudson River R. R. is reported to have exploded April 7, injuring seven men. Parts of the locomotive were blown a quarter of a mile.

TWO FATAL RAILROAD ACCIDENTS were reported during the past week. A passenger train on the Chicago, Burlington & Quincy R. R., on April 2, crashed into the rear of a freight train about 15 miles north of St. Louis, Mo., and a mile south of Spanish Lake. One man was killed and five were injured. The cause is said to be the engineer's failure to detect a stop signal at Spanish Lake station. On April 4 a heavy locomotive drawing a coal train over the Bald Eagle Valley R. R., when nearing the junction of the Philadelphia & Lake Erie tracks in Lock Haven, Pa., left the rails, ran across the paving and nearly collided with the station. A brakeman riding on the pilot of the engine was knocked under the wheels and killed. The eastbound "Continental Limited" on the Wabash R. R. was derailed and wrecked by a defective rail at Catlin, Ill., about six miles from Danville, Ill. Five persons were severely injured. The rail causing the trouble is said to be one of a new lot just laid at this point.

THE TORPEDO-BOAT DESTROYER "TIGER" was rammed by the cruiser "Berwick," during manoeuvres of the Portsmouth Division of the British home fleet off the Isle of Wight, on the night of April 2. The boats were engaged in night manoeuvres in the Channel, without lights, while on their way to Portland. The "Berwick" was steaming ahead slowly when the destroyer attempted to cross her bows but was caught amidships and cut in half. The forward half sank immediately and the after part floated just long enough to enable most on board of it to get life preservers. The "Tiger" was 210 ft. long, 21 ft. beam, 383 tons displacement; she had engines of 6,400 I. HP. for a maximum speed of 30 knots. Her complement was 60 men, of whom 36 were lost. Among this number was Lieutenant W. E. Middletown, commander of the vessel.

A CAR DROPPED from the Chicago South Side Elevated Railroad a few hundred feet north of the Indiana Ave. station on April 7. It is reported that while the train was under good headway, a motor suspension on a forward truck of the first car failed, causing derailment of the car. The momentum of the train pushed this car off the structure. The passengers were piled up in the forward part of the car and badly cut and bruised although no one was killed.

PANAMA CANAL EXCAVATION during March increased in both total and daily amounts over any previous month's record. The total excavation for March, in 26 days, was 3,480,270 cu. yds. or 133,857 cu. yds. per day, as against the best records, made in the month of February, 1908, of 2,945,881 cu. yds. or a daily average of 122,745 cu. yds. for 24 working days. The low rainfall of 0.99 ins. in March no doubt had a great deal to do with the high record made. The detail figures in cubic yards for the past two months are given below:

Steam Shovels.	March.	February.
Culebra Division	1,216,264	1,176,752
Gatun Locks	202,462	146,221
Chagres, Mindi, Miraflores and Cardenas Hill	487,546	304,440
Dredges.		
Colon	515,223	401,967
La Boca	783,281	682,271
	3,205,076	2,741,651
*Accessory works outside Canal prism	275,194	204,230
Total excavation	3,480,270	2,945,881

*Detail of accessory works outside Canal prism:

Steam shovels; Gatun spillway, Obispo and Camacho Diversions, Miraflores locks, Chagres Division	243,531	178,400
Dredges	31,663	25,830

ANOTHER SUBWAY IN NEW YORK CITY was authorized last week by the Board of Estimate and Apportionment. It is a Brooklyn north-south route, and is to extend from the eastern approach of the Manhattan bridge south along Fourth Ave. to 43d St. A curious feature of the situation is the fact that the margin between the city's present debt plus obligations already engaged, and the constitutional debt limit (10% of the assessed valuation of property) is not sufficient to build this subway. The Comptroller has stated that for this reason he would refuse to approve contracts for the proposed subway until there is money enough in sight to cover the cost.

SAFETY DEVICES such as lighted lamps that will not explode when turned upside down, containers through which lighted gasoline can be poured without exploding, a model house fireproofed within and without, a mine gallery constructed with steel instead of wood, safety davits, signal lights, life buoys, collapsible life boats, ambulances and emergency boxes, are among the exhibits to be shown at the Exposition of Safety Devices to open April 13th, at the rooms of the American Museum of Safety Devices, 231 West 39th St., New York. There is no charge for space, and inventors and makers are invited to take part by sending their devices to Dr. William H. Tolman, Director, at the Museum. Among the present exhibitors are the Carnegie Steel Co., Westinghouse Air Brake Co., American Bridge Co., Union Switch and Signal Co., Yale & Towne Mfg. Co. and the Travelers' Insurance Co. Three gold medals will be awarded for the best safety devices in transportation, mining and for motor boats and motor cars.

THE FOUR EAST RIVER TUNNELS of the Pennsylvania Railroad at New York City have all been connected, the meeting of the shields on the last one, Tube A, having taken place on March 18. Tube D, the first of the four tubes to be joined, was connected on Feb. 22. To celebrate the final joining of these tunnels and the end of the dangerous and difficult stage in one of the most hazardous pieces of tunnel construction ever undertaken, a dinner was given in New York City on the evening of April 2 by S. Pearson & Son, the contracting firm which has executed this notable piece of work. The dinner was held at Sherry's and the 200 guests included representative engineers, contractors and railway officers. Mr. E. W. Moir, M. Am. Soc. C. E., Vice-President and Chief Engineer of the contracting firm, presided, and the after-dinner speakers included President Jas. McCrea, Vice-President John P. Green and General Counsel Geo. V. Massey of the Pennsylvania R. R., Mr. Henry Japp, M. Am. Soc. C. E., Director and Managing Engineer and Geo. W. Wickersham, General Counsel for S. Pearson & Son., and Dr. Henry S. Pritchett, President of the Carnegie Foundation.

Each guest at the dinner received a souvenir consisting of a section of the cutting edge of one of the shields, worn and gouged by the severe ordeal of its journey for nearly 2,000 ft. through the refractory material underlying the East River. These heavy pieces of steel were mounted for paper weights by the Gorham Mfg. Co. and were surmounted by a miniature model of the tunnel-lining sections in sterling silver.

A souvenir book also distributed at the dinner contained photographs of the leading men connected with the work and a list of names of those who had taken responsible part in it either for the railway company or the contractors, including superintendents, foremen, inspectors, timekeepers, clerks, draftsmen, rodmen, etc.

The following figures convey some idea of the magnitude of the work:

Contract signed between the Pennsylvania Tunnel & Terminal R. R. Co. and S. Pearson & Son, Inc.	July 7, 1904
Length of the four tunnels	24,704 lin. ft.
Distance from center of Long Island shaft to Manhattan shaft	3,950 lin. ft.
Outside diameter of the tunnels	23 ft.
East Ave. tunnels started westward under L. I. City	Sept. 23, 1904
East Ave. tunnels finished to Front St., L. I. City	Dec. 12, 1907
Long Island City steel caisson shafts started sinking	June 13, 1905
Long Island shield driving started westward under air pressure	June 1, 1906
Sinking weight of the two Long Island City caissons	14,000 tons
Manhattan steel caisson shafts started sinking	Apr. 2, 1905
Manhattan started shield eastward under air pressure	Oct. 5, 1905
Shield driven tunnels met under river	Mar. 18, 1908
Holes in rock drilled by machines for blasting	3.50 miles
High explosives used for blasting	320 tons
Timber used in the work	15,000,000 ft. B. M.
Total excavation done	480,000 cu. yds.
Iron and steel lining	100,000 tons
Bolts for uniting above	1,250,000
Cement and sand used round lining	1,750,000 bags
Watertight joints between plates of lining	171 miles
Concrete in works	150,000 cu. yds.
Conduits formed for electric cables in tunnels	225 miles
Structural steel and iron in caissons, sumps, etc.	3,629 tons
Atmospheric air compressed	42,000,000,000 cu. ft.
Energy used for all purposes in connection with the work	92,000,000 HP.-hrs.
Electric energy for power and lights	5,700,000 KW.-hrs.
Hydraulic rams of shields traveled a distance of nearly	300 miles
Narrow gage tunnel cars hauled a distance of nearly	450,000, miles
Electric elevators at shafts traversed a distance of	60,000 miles
Max. capacity of compressed air machinery	11,300 HP.
Total number of men passed by doctors and who actually went into compressed air	12,752
Number of nationalities represented in the above	42
Total max. horsepower capacity of combined plant	15,200

CEMENT PRODUCTION IN THE UNITED STATES for the calendar year 1907 has been officially announced by the U. S. Geological Survey. The total production of hydraulic cement was 52,230,342 bbls. valued at $55,903,851, as against 51,000,445 bbls. valued at $55,302,277 in 1906. Of the above total quantity in 1907, 48,785,389 bbls. were Portland cement with a value of $53,992,551; 2,887,700 bbls. were natural cement, with a value of $1,467,302, and 557,252 bbls. were puzzolan, with a value of $443,998. Comparative amounts of the production of Portland cement within the past four years are as follows: 1904, 26,505,881 bbls.; 1905, 35,246,812 bbls.; 1906, 46,463,424 bbls.; 1907, 48,785,389 bbls. It will thus be seen that the increase in production in the past year fell off as compared to recent years. In Engineering News, Oct. 17, 1907, p. 406, there was published a statistical account of the production of cement up to that time.

THE TYPHOID FEVER EPIDEMIC at Peekskill, N. Y., which assumed "considerable proportions in the latter part of January," 1908, is attributed by the monthly bulletin of the New York State Department of Health for February, 1908, to pollution of the Peekskill water supply by a camp of foreign laborers in the Peekskill drainage area. These laborers are employed by contractors for portions of the Catskill supply for New York City. The bulletin may be quoted from as follows:

> This camp and its immediate environment were found to be in a very insanitary condition, human excreta being visible at many points, so situated that contamination of the Peekskill water supply was inevitable. This water supply was supposed to be protected by rules drawn up by the State Department of Health, but little or no attempt at the proper enforcement of these was being made by the local authorities. An inspector who had been patrolling the watershed to detect violations of the rules was discharged in the fall, and no policing of the district had been made since them. The recent orders of the State Department of Health ordering a thorough investigation of the watershed had not been complied with.
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> What was found by the Department's representatives would have been discovered and the nuisances suppressed had the local authorities performed their duties and carried out the advice of the State Department of Health, and the price paid for this neglect has been a heavy one. It is to be hoped that the lesson may be heeded by other